FAIRCHILD
INSTRUMENTATION

F-1

Instruction Manual for Model 7050 Digital Multimeter

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FAIRCHILD
INSTRUMENTATION

Instruction Manual for Model 7050 Digital Multimeter

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EQUIPMENT WARRANTY

1. Seller warrants equipment of its manufacture against defective materials or workmanship for a period of one year from date of shipment.

2. The liability of Seller under this warranty is limited, at Seller's option, solely to repair, replacement with equivalent Fairchild equipment, at an appropriate credit adjustment not to exceed the original equipment sales price, of equipment returned to the Seller provided that (a) Seller is promptly notified in writing by Buyer upon discovery of defects, (b) upon receipt of written authorization from Seller the defective equipment is returned to Seller, transportation charges prepaid by Buyer, and, (c) Seller's examination of such equipment discloses to its satisfaction that defects were not caused by negligence, misuse, improper installation, accident, or unauthorized repair or alteration by the Buyer.

3. This warranty does not include mechanical parts failing from normal usage nor does it cover limited life electrical components which deteriorate with age such as vacuum tubes, choppers lamps, etc. In the case of accessories, i.e., card punches, typewriters, etc., not manufactured by Seller, but which are furnished with the Seller's equipment, Seller's liability is limited to whatever warranty is extended by the manufacturers thereof and transferable to the Buyer.

4. This warranty is expressed in lieu of all other warranties, expressed or implied, including the implied warranty of fitness for a particular purpose, and of all other obligations or liabilities on the Seller's part, and it neither assumes nor authorizes any other person to assume for the Seller any other liabilities.

5. The aforementioned provisions do not extend the original warranty period of any article which has been either repaired or replaced by Seller.

SECTION I
GENERAL INFORMATION

1-1. INTRODUCTION

1-2. The Model 7050 Digital Multimeter is a low cost accurate 3-digit instrument suitable for use in production, general test, servicing, and educational applications. It is also widely used as a replacement for analog-type meters and panel indicators. The instrument will measure dc voltage from 0.000 to 1000 volts with 0.1% accuracy. Full scale ranges are 1.500 V, 15.00 V, 150.0 V and 1000 V. The input can be floated 500 V above ground. The input impedance is greater than 1 kMΩ on the 1.500 V range and 10 MΩ on the other 3 dc ranges.

1-3. The Model 7050 will measure resistance from 0.000 to 15.00 MΩ in five full scale ranges of 1.500 kΩ, 15.00 kΩ, 150.0 kΩ, 1.500 MΩ, and 15.00 MΩ. The voltage and resistance ranges are selected by a single front panel control.

1-4. The measuring technique utilized in the Model 7050 is dual-slope integration. This technique combines the noise rejection capabilities of integration with the accuracy and stability of automatic comparison to an internal standard. The input amplifier in the instrument is chopper-stabilized with a MOS FET and provides high stability and low drift characteristics.

1-5. The instrument performs six measurement samples per second, ensuring a fast measurement response time in the event of a change in source voltage or resistance. Also, an "infinite hold" capability is provided that allows the operator to take-and-hold a reading. This is accomplished by connecting a short between two HOLD terminals on the front panel, or remotely by means of an optional measurement probe.

1-6. The use of Fairchild micrologic elements in the instrument ensures precision operation and high reliability as well as a high speed readout response.

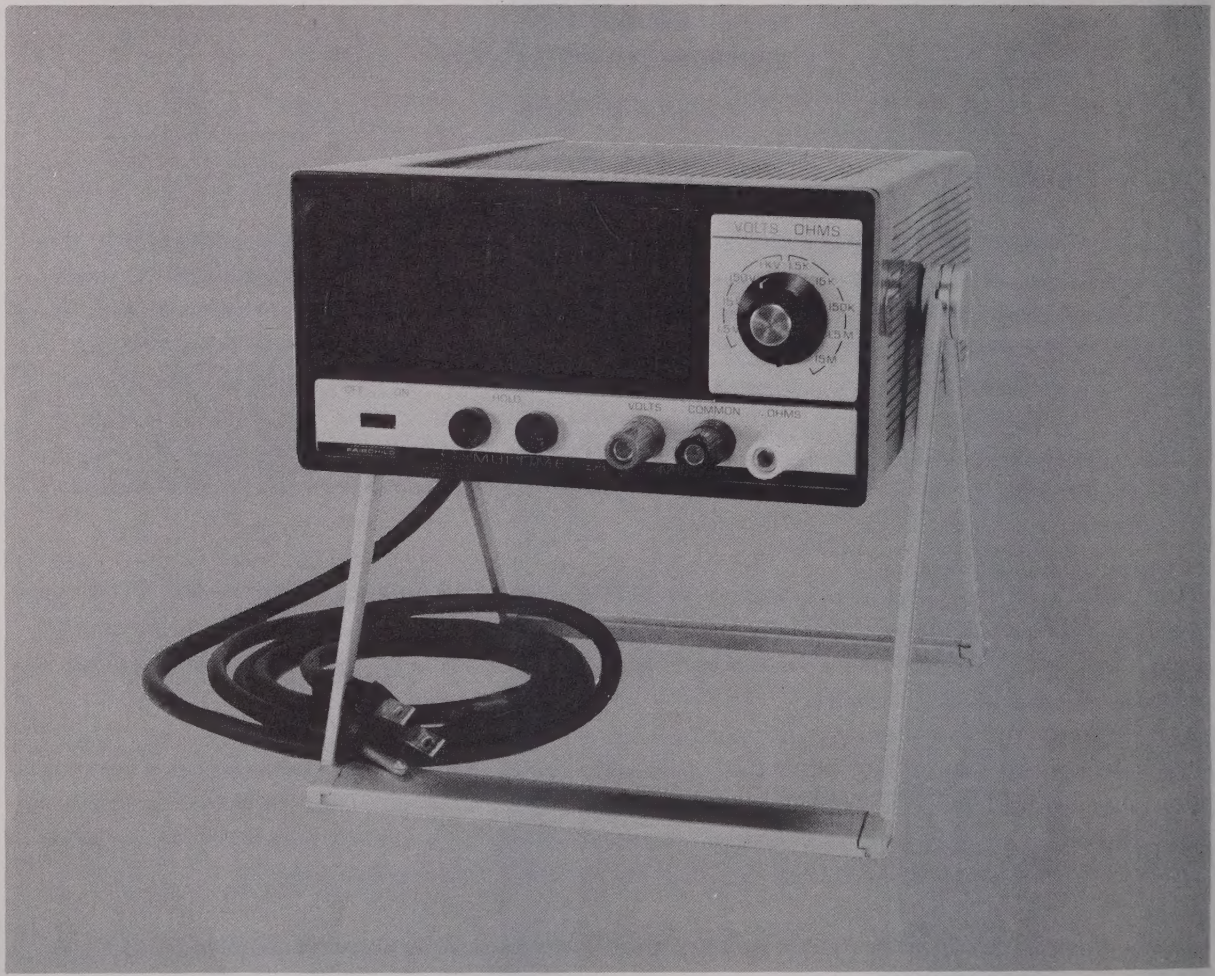


Figure 1-1. Model 7050 Digital Multimeter with Optional Tilt Stand

1-7. ACCESSORIES AVAILABLE

1-8. Optional equipment available for use with the Model 7050 is listed below:

a. Precision Current Shunts: Used with Model 7050 to perform dc current measurements. Shunts for measuring five full scale ranges from 150.0 μA to 1.500 A are available. See table 1-1. The five shunts may be ordered as a kit. Fairchild stock number 93000259 .

b. Carrying Handle: Converts to a self-locking tilt stand. Provides convenient portage and adjustable positioning features. Fairchild stock number 93000258.

c. Rack Mounting Kit: Adapts instrument to a standard rack mounting configuration, 3-1/2" high and 19" wide. Provides capability of mounting one or two Model 7050's side-by-side. Fairchild stock number 93000256.

d. Special Probe: Permits remote enabling of "infinite hold" feature. Allows operator to make measurements in close or otherwise inaccessible equipment areas. Fairchild stock number 93000257.

e. Optional Power Transformer: Adapts power input circuit so that instrument will operate from 220, 115 or 100 V line voltages. Fairchild stock number 20017211. Refer to table 1-1 for additional description.

1-9. DIMENSIONS AND WEIGHT

1-10. Figure 1-2 is an outline drawing of the Model 7050. The weight of the instrument is 4 pounds (1.9 kg).

1-11. SPECIFICATIONS

1-12. Table 1-1 lists electrical specifications for the Model 7050 Digital Multimeter.

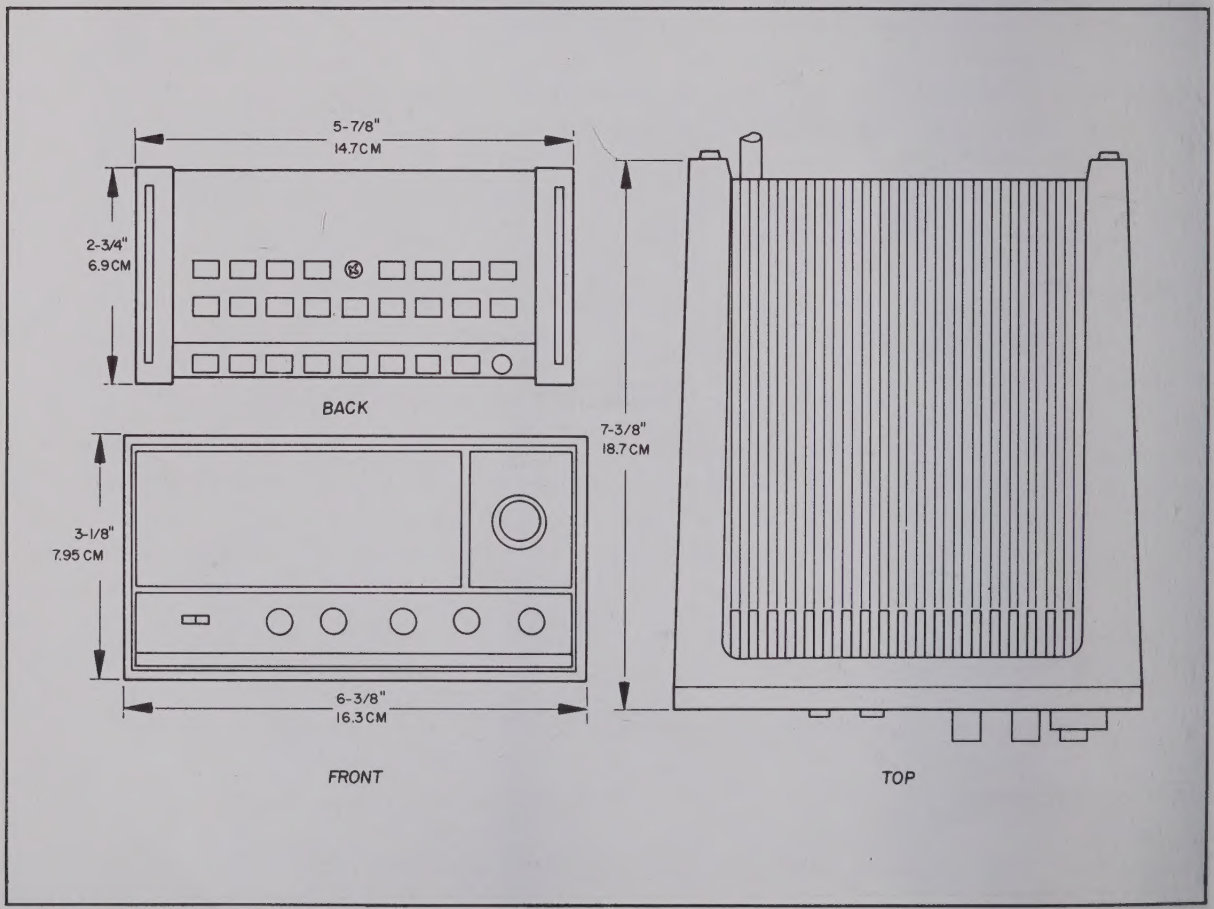


Figure 1-2. Outline Drawing of Model 7050

Table 1-1. Model 7050 Specifications

DC VOLTS

Ranges:	4 ranges, manually selected ±1.500 V full scale ±15.00 V full scale ±150.0 V full scale ±1000 V full scale
Accuracy:	15°C to 35°C ±0.1% of reading, ±1 digit 0°C to 45°C ±0.3% of reading, ±2 digits
Voltage Coefficient:	Above 500 V: 0.0005% per volt
Resolution:	1 mV on 1.500 V range
Response Time :	<5 sec
Input Impedance:	1.500 V >1 kMΩ 15.00 V 10 MΩ 150.0 V 10 MΩ 1000 V 10 MΩ
Overload Protection:	1000 V maximum on any range with no damage.

Table 1-1. Model 7050 Specifications (Cont.)

OHMS

Ranges:	5 ranges, manually selected
	1.500 kΩ full scale
	15.00 kΩ full scale
	150.0 kΩ full scale
	1.500 MΩ full scale
	15.00 MΩ full scale
Accuracy:	15°C to 35°C
	1.500 kΩ ±0.2% of reading, ±1 digit
	15.00 kΩ ±0.2% of reading, ±1 digit
	150.0 kΩ ±0.2% of reading, ±1 digit
	1.500 MΩ ±1% of reading, ±1 digit
	15.00 MΩ ±1% of reading, ±1 digit
	0°C to 45°C
	1.500 kΩ ±0.3% of reading, ±2 digits
	15.00 kΩ ±0.3% of reading, ±2 digits
	150.0 kΩ ±0.3% of reading, ±2 digits
	1.500 MΩ ±3.0% of reading, ±2 digits
	15.00 MΩ ±3.0% of reading, ±2 digits

Table 1-1. Model 7050 Specifications (Cont.)

DC CURRENT (OPTION)

Measurement: A precision shunt resistance is connected across VOLTS - COMMON terminals. Current under test is directed through shunt and resulting voltage drop is measured by the dc voltage measuring portion of the Model 7050.

Ranges:

Full Scale Current	Voltage Range	Shunt Value	Fairchild Stock No.
150.0 μA	1.5 V	10 kΩ ±0.1%	09045091
1.500 mA	1.5 V	1 kΩ ±0.1%	09045101
15.00 mA	1.5 V	100 Ω ±0.1%	09045111
150.0 mA	1.5 V	10 Ω ±0.1%	09045121
1.500 A	1.5 V	1 Ω ±0.3%	09045131

Resolution: 0.1 μA with 10 kΩ shunt

Accuracy:

15°C to 35°C

1.500 A range: ±0.4% of reading, ±1 digit

All other ranges: ±0.2% of reading, ±1 digit

0°C to 45°C

1.500 A range: ±0.6% of reading, ±2 digits

All other ranges: ±0.4% of reading, ±2 digits

Table 1-1. Model 7050 Specifications (Cont.)

READOUT

Three digital readout indicators; one over-range digit; three decimal point indicators; plus (+) and minus (-) polarity indicators; display storage (non-blinking).

POWER REQUIREMENTS

115 Vac ±10%, 50 Hz to 400 Hz, approximately 7 watts
For 220 Vac ±10% order Model 7050 - 220 V
For 100 Vac ±10% order Model 7050 - 100 V

SECTION II
INSTALLATION

2-1. INTRODUCTION

2-2. This section outlines procedures for inspection and initial installation. Reshipment instructions are included in case the instrument must be returned to Fairchild Instrumentation.

2-3. UNPACKING AND INSPECTION

2-4. Before accepting the instrument from the shipper, inspect the crated instrument for external damage. Any sign of external damage must be noted by both customer and shipper, and should be called to the attention of the insurance investigator.

2-5. As soon as the equipment is unpacked, inspect the instrument for damage in shipment. Check for scratches or dents and damaged knobs or connectors. If damage is noted, do not use the instrument unless instructed by the insuring agency.

2-6. POWER REQUIREMENTS

2-7. The Model 7050 is designed to operate from a 115 V ±10%, 50 to 400 Hz power source. It draws approximately 7 watts. Do not connect the instrument to a power source with incorrect voltage or inadequate current rating.

2-8. The Model 7050 is equipped with a three-conductor power cable that grounds the instrument when the connector is plugged into an appropriate receptacle. To preserve this safety feature when operating with a two-contact outlet, use an adapter and connect the pigtail on the adapter to a suitable ground.

2-9. OPERATION CHECK

2-10. The following preliminary operation check may be used to ensure that all components and circuits are in proper operating condition when the instrument is first energized. The procedure provides a quick check for proper functioning, but does not check specifications completely. Refer to section V of this manual for a complete performance check.

a) Connect instrument to 115 Vac power source.

b) Set power ON/OFF switch to ON position. Display panel should light up.

c) Set Function/Range switch to VOLTS/1.5 V and connect short between VOLTS and COMMON terminals. Check that readout is between .000 and ±.001.

d) Set Function/Range switch to OHMS/1.5 K. Move short to OHMS - COMMON terminals. Check that readout is between .000 and ±.001.

e) Remove short and set power ON/OFF switch to OFF. Disconnect instrument from ac power source.

NOTE

The 7050 has a very low internal noise current on the order of 0.2 nAmps. When the voltage input terminals are open circuited with the range switch on the 15 V, 150 V or 1000 V position, (10 MΩ input Z), the reading always will drop to 000. When in the 1.5 V position (>1000 MΩ input Z) the low noise current is accumulated as a voltage across the high input impedance and appears as a slowly increasing numerical value on the readout indicators. In any of the ohms ranges, with the input open, the Model 7050 will read over full scale (1500) since the resistance between terminals is that of the air gap itself.

2-11. RESHIPMENT

2-12. When a damaged instrument is to be returned to the factory for service or repair, contact your nearest Fairchild Instrumentation engineering representative for written permission to ship, shipping instructions, and a shipping form. Such action will ensure expedient repair and return of the instrument.

2-13. RACK MOUNT OPTION

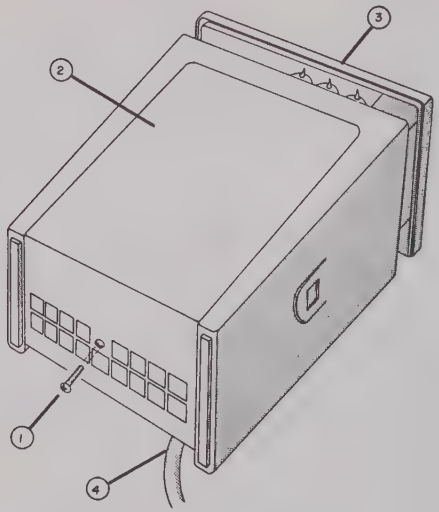
2-14. Instructions for installing the optional rack mounting accessory (Fairchild stock number 93000256) are detailed in figure 2-1.

2-15. CARRYING HANDLE/TILT STAND OPTION

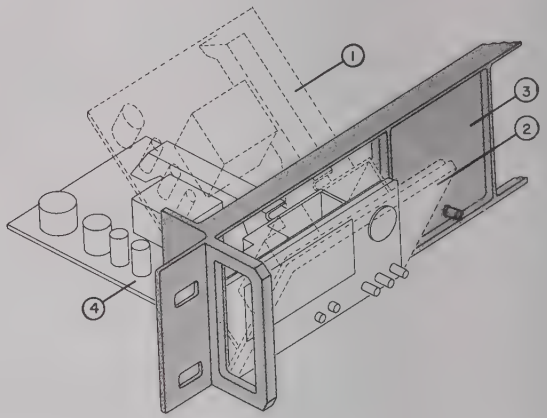
2-16. The optional carrying handle/tilt stand (Fairchild stock number 93000258) may be ordered as a kit. The following is a list of items that make up each carrying handle/tilt stand assembly kit.

DESCRIPTION	QUANTITY	FAIRCHILD STOCK NUMBER
Base Supports	2	64020301
Inner Legs	2	64020291
Outer Legs	2	64020281
Bushings	2	43014561
Retainers	2	30060081
Nylon Washers	8	62407210
Screws, Phillips Head	2	60112830
Lockwashers	2	62300030
Total Items	20	

2-17. Instructions for installing and using the optional carrying handle/tilt stand are given in figure 2-2. Before attempting assembly of the kit determine that all items are included.



a) Remove screw (1) and slide case (2) away from chassis (3). It is not necessary to remove power cord (4).

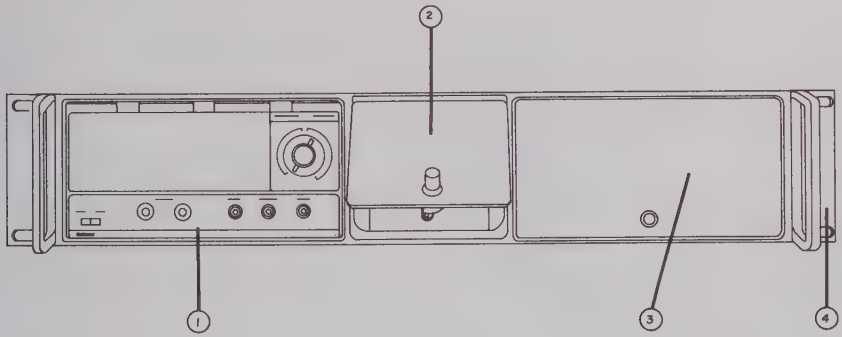


b) Tilt chassis (1) forward approximately 60 degrees. Push front panel (2) through hole in rack mount assembly (3).

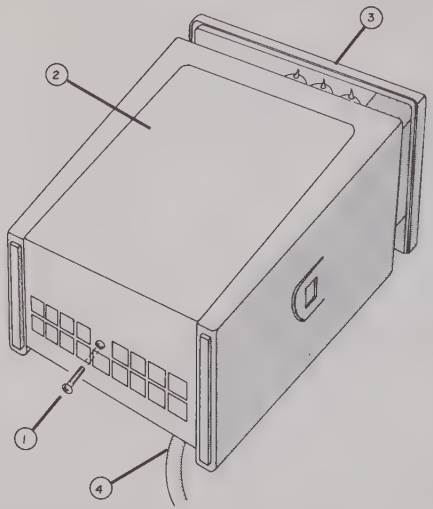
c) Return chassis (4) to horizontal position and move it back until rim on front panel seats into position on rack mount.

d) Replace case, pushing it against rack mount. Replace screw removed in step a).

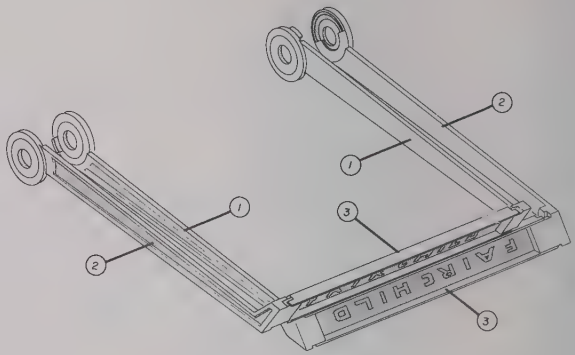
Figure 2-1. Rack Mounting Instructions



e) Figure above shows Model 7050 (1) properly mounted in rack mount assembly. Storage compartment (2) provides room to store special test probes, shunts etc. Compartment (3) permits mounting a second 7050 on the rack assembly (4).



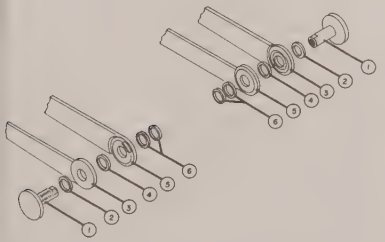
a) Remove screw (1) and slide case (2) away from chassis (3). It is not necessary to remove power cord (4).



b) Assemble legs as shown above. Note that each leg assembly consists of an inner leg (1), an outer leg (2), and a base support (3).

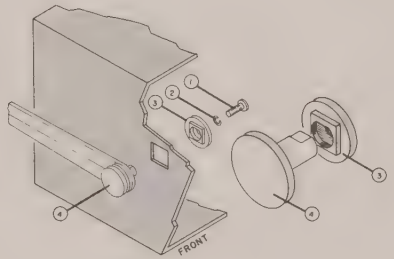
c) Place leg assemblies on a flat surface and offset slightly as shown.

Figure 2-2. Carrying Handle/Tilt Stand Mounting Instructions



d) Connect leg assemblies together using retainers and plastic washers. Order of assembly is retainer (1), plastic washer (2), outer leg (3), plastic washer (4), inner leg (5), and plastic washers (6).

e) Slide case between legs approaching from rear of case, so that square holes in case align with ends of leg assemblies.

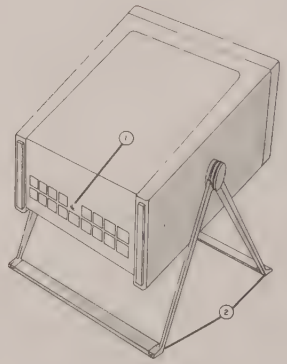


f) Assemble screw (1), lockwasher (2), and bushing (3). Reach inside case and place bushing (3) in square hole in case.

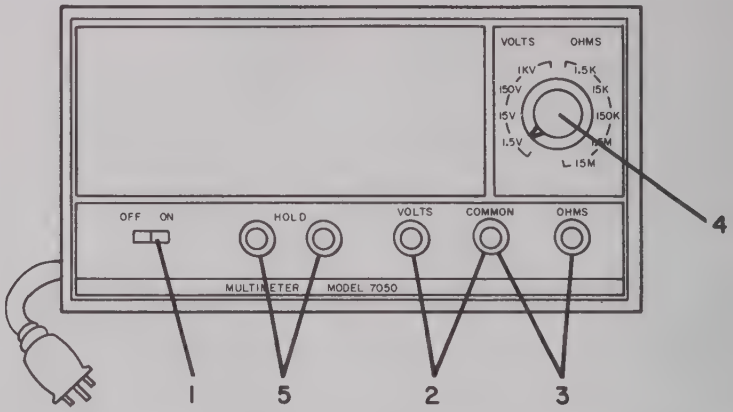
g) Hold bushing (3) in place. Push and turn retainer (4) until "D" on shaft of retainer fits into position inside of bushing (3). Proper retainer (4) - bushing (3) orientation is shown in the blown-up view.

h) Tighten screw (1) from inside case, using a phillips screwdriver with a 2 inch shaft.

i) Secure legs on opposite end of leg assembly to case following same procedure.



j) Replace case and tighten screw (1). Check that stand works properly. When legs (2) are together, instrument should pivot freely; when legs are extended movement should be impeded.



1. Power ON/OFF switch applies primary power to the instrument. On position is to the right.

2. VOLTS terminal (left) and COMMON terminal (center) are input terminals for dc voltage measurements.

3. OHMS terminal (right) and COMMON terminal (center) are input terminals for resistance measurements.

4. Function/Range switch:

   a. Permits measurement of dc volts when switched to VOLTS ranges.

   b. Permits measurement of resistance when switched to OHMS ranges.

5. HOLD terminals allow operator to take-and-hold a single reading when short is connected between the HOLD terminals.

6. Readout Panel gives visual presentation of three digits of data plus one over range digit and decimal point. The most significant digit will indicate 1 or nothing. Function and Range are determined from Function/Range switch setting.

Figure 3-1. Front Panel Description

SECTION III
OPERATION

3-1. OPERATING INSTRUCTIONS

3-2. The following paragraphs describe control functions and give operating instructions for the Model 7050.

3-3. DC VOLTAGE MEASUREMENT

3-4. The Model 7050 will measure dc voltages from 0.000 to 1000 V. Instructions for using the Model 7050 as a dc voltmeter are given in figure 3-2.

3-5. RESISTANCE MEASUREMENT

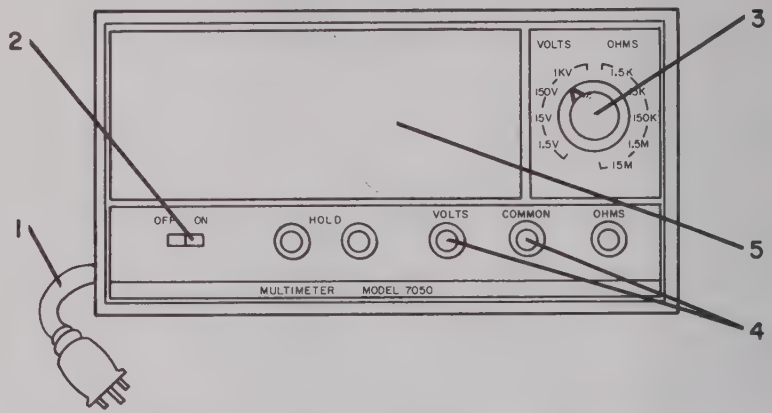
3-6. The Model 7050 will measure resistances from 0.000 to 15.00 MΩ. Instructions for using the Model 7050 as an ohmmeter are given in figure 3-3.

3-7. DC CURRENT MEASUREMENT (OPTIONAL)

3-8. Five precision current shunts are available for use with the Model 7050 in performing measurement of dc current ranging from 0.1 μA to 1.500 A. Instructions for using the Model 7050 as a current meter are given in figure 3-4.

3-9. HOLDING A MEASUREMENT

3-10. To take-and-hold a measurement, simply insert a short between the two terminals labeled HOLD. The reading indicated on the front panel of the Model 7050 will be held until the short is removed.



1. Connect power cord to 115 V outlet.

2. Set ON/OFF switch to ON position.

3. Set Function/Range switch to VOLTS/1 KV.

4. Connect unknown dc voltage across VOLTS and COMMON terminals.

NOTE

The Model 7050 has a very low internal noise current (in the order of 0.2 nA). When the voltage input terminals are open circuited with the Function/Range switch on the 15 V, 150 V or 1000 V positions (10 MΩ input Z), the reading drops to 000. When in the 1.5 V position (>1000 MΩ input Z) the low noise current is accumulated as a voltage across the high input impedance and appears as a slowly increasing numeric value on the readout indicators.

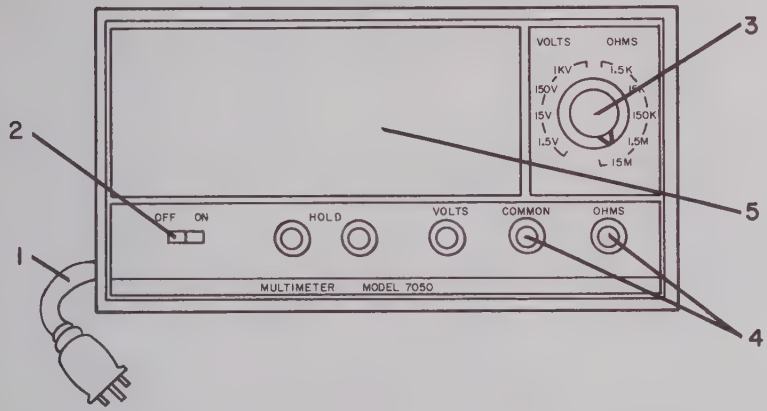
5. Observe reading; if readout exceeds 1000 an overload condition exists. Remove input voltage immediately! Otherwise, reduce Function/Range switch VOLTS setting until proper range is reached. Table below indicates proper readout limits for each setting.

Function/Range setting	Proper readout limits
VOLTS/1.5 V	.000 - 1.500
VOLTS/15 V	1.50 - 15.00
VOLTS/150 V	15.0 - 150.0
VOLTS/1 KV	150 - 1000

CAUTION

DO NOT FLOAT THE METER MORE THAN 500 V ABOVE GROUND OR DAMAGE TO THE INSTRUMENT WILL RESULT.

Figure 3-2. DC Voltage Measurement



1. Connect power cord to 115 V outlet.
2. Set ON/OFF switch to ON position.
3. Set Function/Range switch to OHMS/15 M.
4. Connect unknown resistance across OHMS - COMMON terminals. Keep leads as short as possible.

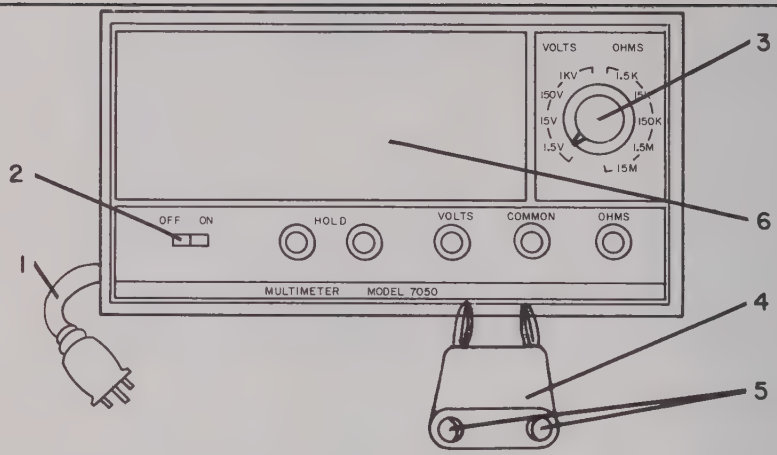
NOTE

In any of the OHMS ranges with the input open, the Model 7050 readout will exceed full scale (1500) because the resistance between the terminals is that of the air gap.

5. Observe reading; decrease Function/Range switch OHMS setting until proper range is reached. Table below indicates proper readout limits for each setting. Readout is in KΩ or MΩ as indicated by the Function/Range switch setting.

Function/Range Setting	Proper Readout Limits
OHMS/1.5 K	.000 - 1.500
OHMS/15 K	1.50 - 15.00
OHMS/150 K	15.0 - 150.0
OHMS/1.5 M	.150 - 1.500
OHMS/15 M	1.50 - 15.00

Figure 3-3. Resistance Measurement



1. Connect power cord to 115 V outlet.
2. Set ON/OFF switch to ON position.
3. Set Function/Range switch to VOLTS/1.5 V.
4. Connect precision shunt resistance across the VOLTS - COMMON terminals. Correct value of shunt for each full scale current range is given below.

Full Scale Current Range	Correct Value of Shunt Resistance
150.0 μA	10 kΩ
1.500 mA	1 kΩ
15.00 mA	100 Ω
150.0 mA	10 Ω
1.500 A	1 Ω

5. Connect unknown current source in series with terminals of shunt fixture.
6. Observe reading; if readout exceeds 1.500, an overload condition exists. Decrease value of shunt resistance to bring readout within permissable limits.
7. Mentally convert reading to current measurement using formula below. Place decimal point as shown on applicable full scale current range.

$$I_{unknown} = \frac{V_{reading}}{R_{shunt}}$$

Figure 3-4. DC Current Measurement

SECTION IV
THEORY OF OPERATION

4-1. INTRODUCTION

4-2. This section contains a discussion of the design and operating principles of the Fairchild Model 7050 Digital Multimeter. Theory of operation is discussed first at block diagram level and then at detailed circuit level. The complete schematic diagram of circuits discussed in this section is included in section V of this manual.

4-3. OPERATING PRINCIPLES

4-4. The Model 7050 Digital Multimeter is a single chassis, self contained unit that can be operated from 50-400 Hz primary power. The measurement circuitry can be switched so that the instrument will measure either dc volts or resistance. The paragraphs that follow describe each of these measurement circuits in terms of the block diagram and timing diagram shown in figure 4-1.

4-5. DC VOLTAGE MEASUREMENT

4-6. Voltages from 0.001 Vdc are applied across the VOLTS and COMMON terminals. Function/Range switch S1 is positioned for proper attenuation of the input signal. Critical resistors in the attenuator are made adjustable for calibration purposes. The attenuated signal appears at the input to a chopper stabilized amplifier. A dc amplifier provides additional voltage gain. Within the dc amplifier, polarity of the input signal is sensed. Polarity indication is discussed in detail in paragraph 4-21. The output of the dc amplifier is connected back through the chopper to the chopper amplifier input. Operation is such that when the output from the dc amplifier equals the input to the chopper amplifier, the circuit is nulled. Nulling action is described below.

4-7. Chopper drive is derived from the clock and decade counters. Drive frequency is 120 Hz. As chopper Q16 is switched off, the two amplifier stages amplify any error signal (difference between input to chopper ampli-

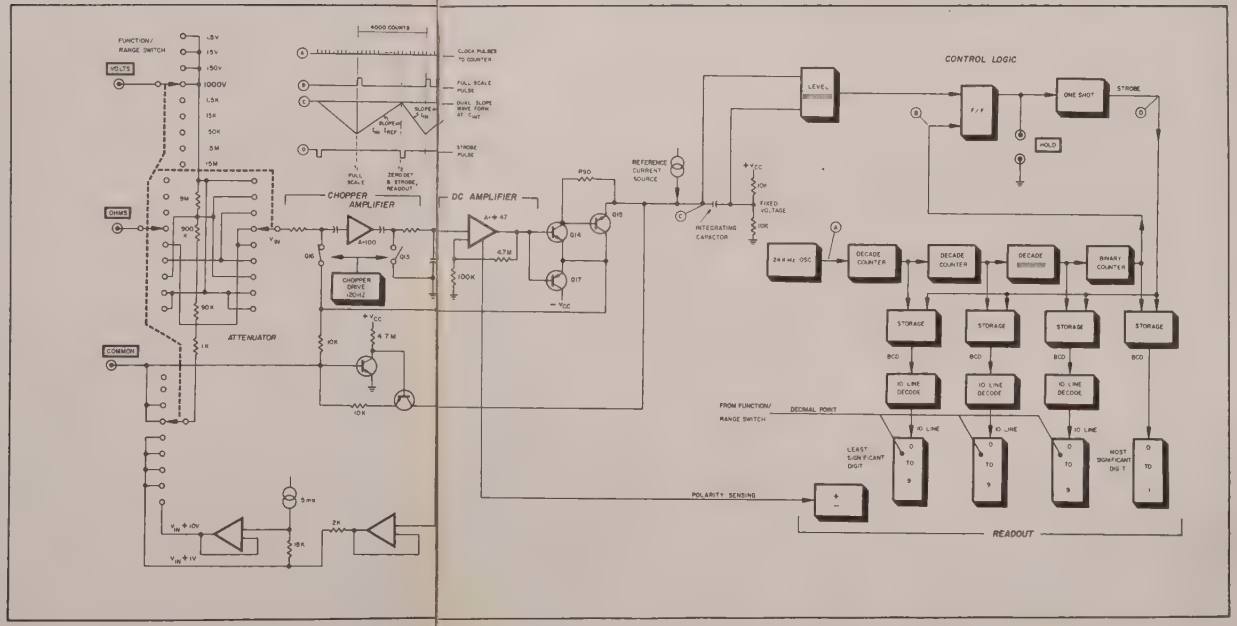


Figure 4-1. Digital Multimeter Block Diagram

fier and output from dc amplifier) and feed the amplified error signal back, in phase, to one side of the chopper. The effect is to reduce the original error signal. This action continues until the output from the dc amplifier equals the input to the chopper amplifier. At this time the amplifier is nulled, the voltage across the chopper is zero, and the dc amplifier output is impressed across 10 K resistor R47.

4-8. The current that flows through R47 draws charge from the integrating capacitor. The path by which current flows to R47 is determined by polarity of the input signal; but it is important to note that current is always drained FROM the integrating capacitor regardless of the polarity of the unknown input signal. Current is drawn from the integrating capacitor through the emitter followers in the dc amplifier output circuit. For input signals of positive polarity Q14 conducts, and the integrating capacitor discharges at a rate proportional to the magnitude of the unknown input signal. For negative polarity, Q17 conducts and current is drawn through Q23. A change in the magnitude of the unknown input signal results in a proportional change in the current that drains from the integrating capacitor.

4-9. Each measurement cycle consists of two parts. During the first part, current is drained from the integrating capacitor by the unknown current while clock pulses feed continuously into the counter. At 4000 counts from the clock, the counter overspills to 0000 and the second part of the measurement cycle begins.

4-10. At overspill (t_1 on the timing diagram, figure 4-1), a full scale pulse is emitted. This pulse triggers FF1 which in turn closes reference current switch Q9. Now the integrating capacitor recharges at a rate proportional to the reference current minus the unknown current (t_1 to t_2 on the timing diagram). When the voltage across the integrating capacitor reaches zero (t_2) the level detector changes the state of FF1 which then (a) turns off current reference switch Q9 and (b) enables the strobe one-shot multivibrator. The strobe pulse performs two functions:

a) It temporarily disables the clock.

b) It gates the buffer/storage units so that the count stored at that particular instant is presented to the readout tubes for display. The input circuit, the measurement circuit, and the clock are calibrated to give a direct visual readout in volts.

The clock is delayed just long enough to prevent a count during the strobe pulse. It then resumes generating pulses while the unknown input current again discharges the integrating capacitor until another full scale pulse is generated. Measurement cycles automatically continue in this fashion and readout is continuous. However, the automatic measurement cycle is disrupted if a short is inserted between the HOLD terminals. The short disables the strobe pulse and the last display is held until the short is removed.

4-11. RESISTANCE MEASUREMENT

4-12. Resistance to be measured is connected between the OHMS and COMMON terminals. FUNCTION/RANGE switch S1 is positioned to program a calibrated current that flows through the unknown resistance. The resulting voltage drop is measured with the basic dc measuring system. The test current is generated in a feedback circuit that consists of an amplifier and ranging resistors. The ranging resistors are switched into the circuit by the Function/Range switch and are used to program test currents of 100 nA, 1 μA, 100 μA, or 1 mA. The voltage appearing at the input to the chopper-stabilized amplifier is proportional to the value of the unknown resistance. The dc section of the instrument measures proportional voltage and readout is given as kΩ or MΩ.

4-13. DETAILED CIRCUIT DESCRIPTION

4-14. The following paragraphs describe in detail the operation of the individual circuits within the Model 7050.

4-15. Voltages to be measured are applied between the VOLTS and COMMON terminals. Resistances are applied between OHMS and COMMON terminals. Input signals are routed to a Function/Range switch that consists of six ganged wafers. One wafer (S1-C) switches the input COMMON when the Function is changed. Another (S1-F) sets range indication by grounding the cathode of the proper decimal point indicator in the readout tubes. One wafer (S1-D) grounds the cathodes of the polarity indicating lamps when the Function/Range switch is in any of the VOLTS ranges. The remaining three wafers (S1-A, B, E) route the input signal through attenuating resistors to the input amplifier. Potentiometer R45 calibrates the 1000 V range. R36 calibrates the 150 V range. R28 calibrates the 15 V range.

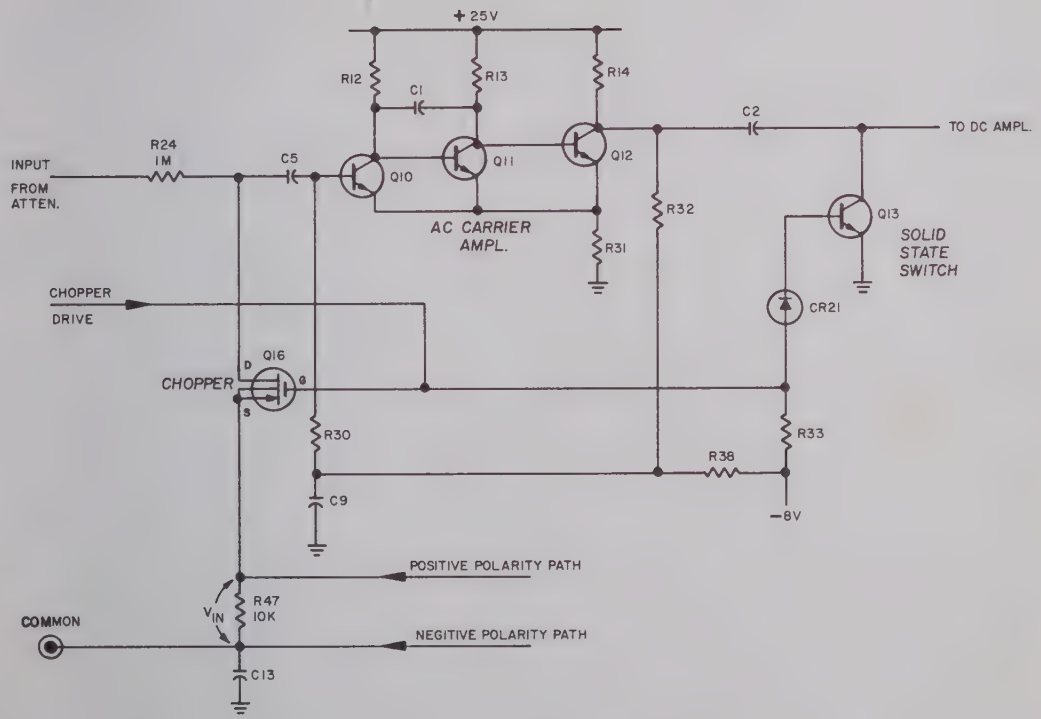


Figure 4-2. Chopper Amplifier

4-16. INPUT AMPLIFIERS

4-17. The attenuated input signal is applied to the chopper stabilized amplifier. A metal oxide silicon field effect transistor (MOS FET), shown as Q16 on figure 4-2, is utilized as the chopper. The chopper is driven on and off alternately with solid state switch Q13. The drain lead of Q16 is tied to the input of the ac carrier amplifier. The source lead is tied to the output of the dc amplifier for a closed loop. When chopper Q16 is on, the potential at the junction of R24 and C5 is chopped to the level of the dc amplifier output. As the chopper is driven on, any potential difference that exists between the amplifier input and output is coupled through C5 to the amplifier input as an error signal. This error signal is amplified and fed back in phase to the source lead of Q16. When the voltages at the dc amplifier output and ac carrier amplifier input reach the same level, the amplifier is stabilized and the total equivalent unknown input signal is impressed across 10 kΩ resistor R47. The current that must flow through R47 draws charge from the integrating capacitor C13.

4-18. CHOPPER AMPLIFIER: When chopper Q16 is driven on, the voltage at its drain (V_{in}) is chopped to the level of its source. The voltage step (it may be positive or negative according to polarity of the input signal) is coupled through C5, amplified and inverted in Q10, Q11, Q12, and then is coupled through C2 to the collector of Q13. Q13 is off at this time so the voltage step is integrated (filtered) by R15 and C6 and applied to the input of the dc amplifier.

4-19. When Q16 goes from on to off, any voltage change at its drain is amplified and appears inverted at the col-collector of Q13. But this time Q13 is turned on so the signal is grounded.

4-20. DC AMPLIFIER: Transistors Q7 and Q8 comprise a differential amplifier as shown in figure 4-3. The voltage at the base of Q8 follows the voltage at the base of Q7. Emitter follower Q14/Q17 conducts (Q14 conducts for input signals of positive polarity; Q17 conducts for input signals of negative polarity) and the voltage step is fed back to the source of Q16. The step is in phase with the input signal; therefore the voltage across the chopper approaches zero. Diodes CR18 and 19 comprise a clamp for positive polarity input signals. R95 and CR20 comprise a clamp for negative polarity input signals.

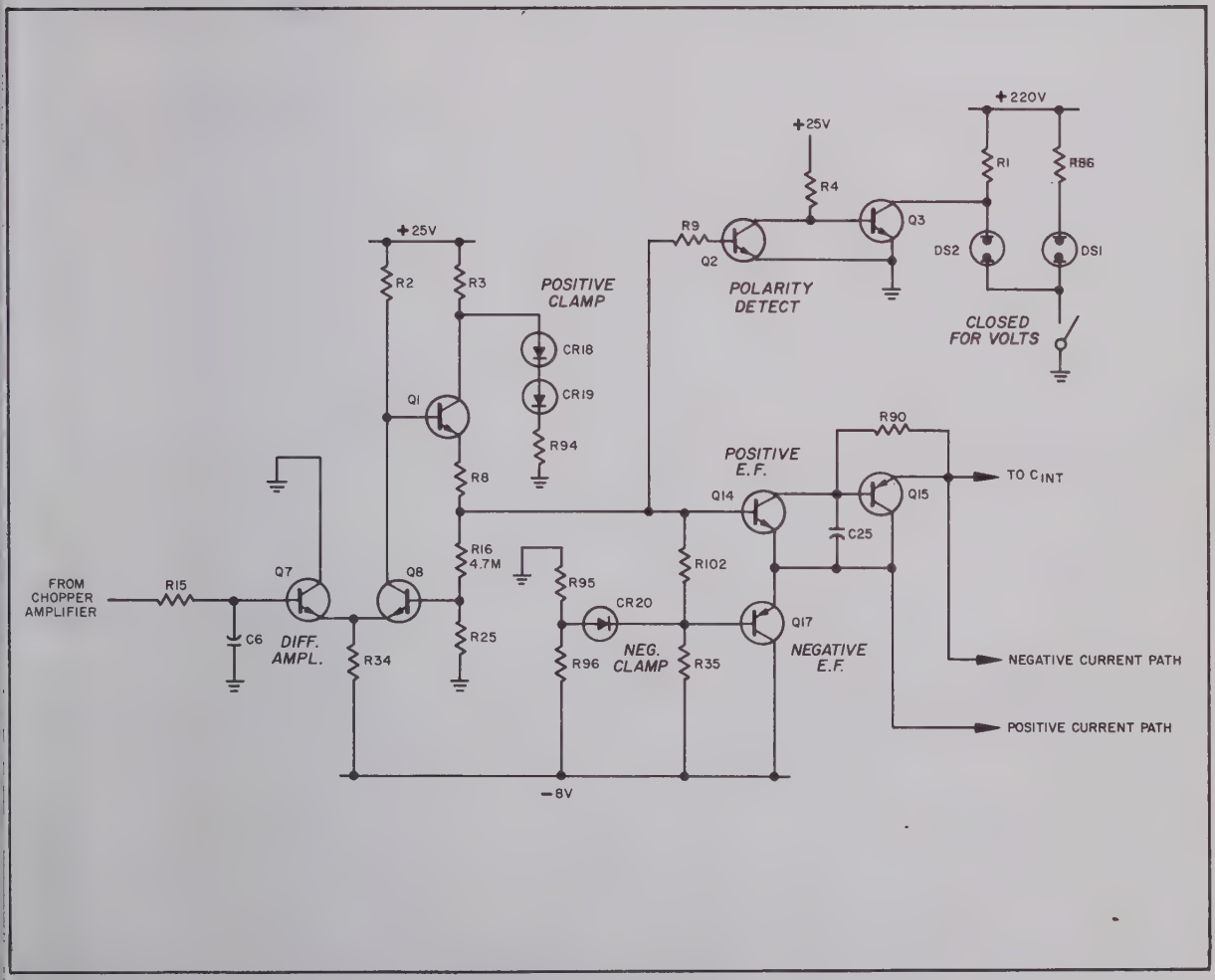


Figure 4-3. DC Amplifier

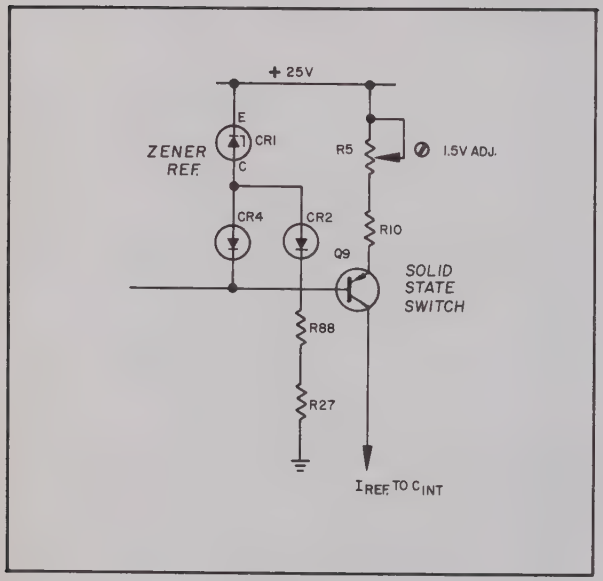


Figure 4-4. Current Reference Source

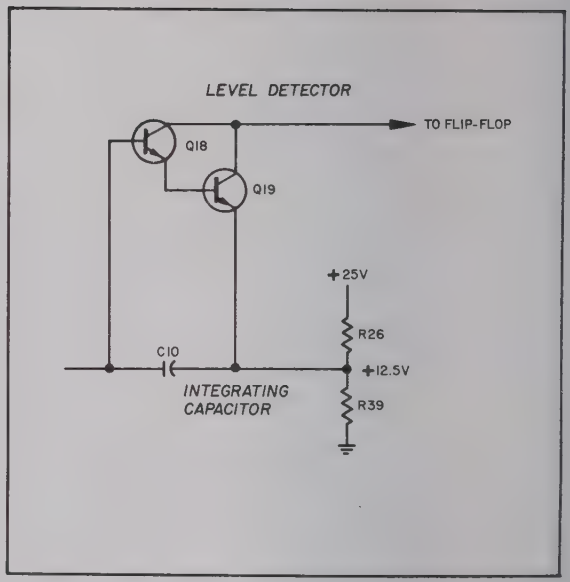


Figure 4-5. Integrator Capacitor and Level Detector

4-21. POLARITY INDICATION: The polarity indicator consists of lamps DS1 and DS2. When ionized, DS1 presents a horizontal bar of light at the readout panel and DS2 presents a vertical bar of light. The two lamps function together to give +(both lamps on) or -(DS1 on, DS2 off).

4-22. When a voltage range is selected, the cathodes of DS1 and DS2 are set to ground via S1-D. The lamps' anodes are connected through 100 kΩ (R1 and R86) to +200 V. In addition, the anode of DS2 is connected to the collector of Q3 in the dc amplifier. For dc voltage inputs of negative polarity, Q3 is turned on so that DS2 is held off. DS1 remains ionized and a negative indication results. For positive-polarity input voltages, Q3 is turned off by solid state switch Q2. Then the voltage at the anode of DS2 rises to allow the lamp to light and give the vertical bar-portion of the (+) indication.

4-23. REFERENCE CURRENT SOURCE

4-24. The reference current that recharges the integrating capacitor during the second part of each measurement cycle is delivered by Q9. See figure 4-4. This current generator is switched off when the zero detector is enabled and held off until the full scale pulse is emitted. Reference for the current source is established by zener diode CR1. When Q9 is held off, the current flowing through CR1 is drained through CR2 to ground. When Q9 is switched on, the 6.8 V zener breakdown across CR1 fixes the voltage at the base of Q9. Q9 conducts and produces a stable reference current. Potentiometer R5 adjusts the current amplitude.

4-25. INTEGRATOR, C10

4-26. One side of integrating capacitor C10 is connected to a voltage divider (R26/R39) that fixes the voltage to +12.5V. Refer to figure 4-5. The voltage on the other side of C10 is discharged during the first part of a measurement cycle by the input signal. During the second part of the cycle it is re-charged by a current equal to the reference current minus the input current. When the voltage returns to +12.5V (plus a small offset voltage), the level detector is triggered.

4-27. LEVEL DETECTOR

4-28. The level detector consists of transistors Q18 and Q19, connected in a Darlington configuration. This configuration (shown in figure 4-5) provides high current gain. When the voltage across C10 reaches zero volts (i.e. 12.5 V on both sides) plus a small offset, the base-emitter junction of Q18 and Q19 become forward biased. The voltage at the collector of Q19 drops and the flip-flop steering transistor Q43 is turned on.

4-29. FLIP-FLOP

4-30. Flip-flop Q5/Q6 controls action of the current reference switch and the strobe generator. Every time the counter reaches full scale, the last counting unit emits a positive spike (full scale pulse). This pulse triggers the flip-flop via steering diode CR6. The positive pulse turns Q5 off and Q6 is turned on through regenerative coupling.

When Q5 goes off it allows current reference switch Q9 to conduct, and current from the reference source flows into the integrating capacitor. When the capacitor has recharged, the zero detector is enabled and produces a negative going output pulse which turns on solid state switch Q43. This turns Q6 off. When Q6 goes off, Q5 goes on through regenerative coupling. When Q5 goes on the voltage at its collector goes high and the positive spike, a) turns current reference switch Q9 off, and b) triggers the strobe one-shot multivibrator.

4-31. STROBE ONE-SHOT AND READOUT HOLD

4-32. The strobe one-shot multivibrator consists of transistor Q20 and RC network R40-R42, C11. At time t_2 (zero det) in the measurement cycle, Q5 in the flip-flop goes on and produces a positive pulse output. The positive pulse is coupled through C11 to turn Q20 off. Values of C11, R40-R42 are chosen to hold Q20 off for 5 μsec. Hence the strobe pulse is a -0.5 V pulse of 5 μsec duration. The strobe pulse a) turns the clock off temporarily and b) gates the buffer storage units so that the count in the counting units can be displayed.

4-33. CLOCK

4-34. The time base used in the Model 7050 is a 24 KHz oscillator. The oscillator consists of an FS μL 914 Dual 2-Input Gate whose outputs have been cross-connected to form a bistable oscillator. R79, R85 and C20, C22 are chosen to give an output frequency of 24 KHz. The equivalent circuit of this micrologic component is shown in figure 4-6.

4-35. COUNTER AND READOUT

4-36. The 24 kHz clock output drives three cascaded decade counters (CμL 958 elements) and one binary counter (μL 926 element). Each CμL 958 element consists of four binary triggered flip-flops modified by a feedback loop to count in 1-2-4-8 binary-coded-decimal. Figure 4-7 shows the base connections and the table of output states for a typical CμL 958 element. The BCD count produced in the decade counters is stored in FS CμL 959 Buffer/Storage elements until a strobe pulse occurs. A strobe pulse trigger the storage elements, allowing each to them to transfer its BCD data to a CμL 960 decimal decoder/driver.

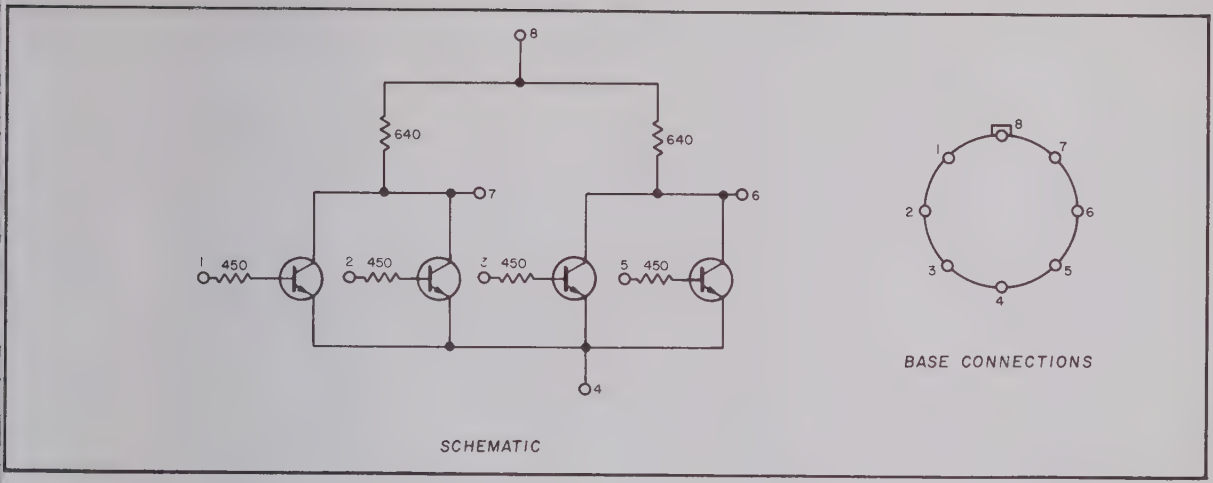
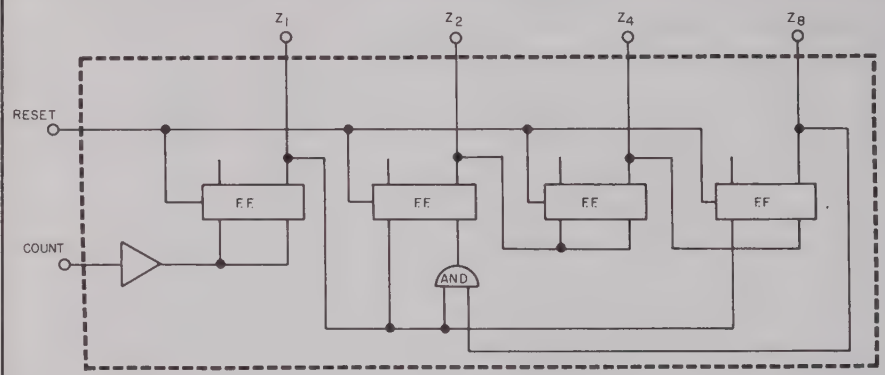


Figure 4-6. FS μL 914 Dual 2-Input Gate

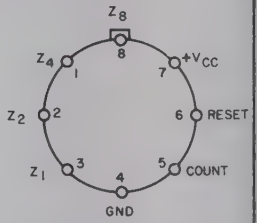
4-37. A CμL 959 buffer/storage unit consists of four gated latch circuits and a common gate driver. Input characteristics of the latch circuits match the CμL 958 decade counter output characteristics. The buffer allows the state of the counter outputs to be sampled and held for an indefinite amount of time. Each time a strobe pulse occurs, the CμL 958 counter outputs are transferred into the buffer elements. Operation of a typical CμL 959 buffer/storage element is summarized in figure 4-8.

4-38. The CμL 960 Decimal Decoder/Driver units accept the 1-2-4-8 BCD output from their respective storage elements and transform the BCD count into 10 mutually exclusive outputs which directly control the ionizing potentials of the gas filled, cold cathode display tubes. Ten individual lines between each driver/tube pair provide for a one digit display of any number from 0 to 9. Operation of the FS CμL 960 Decade Decoder/Driver is depicted in figure 4-9.

4-39. As the count exceeds 999, the "8" output from the last FS CμL 958 element goes high and drives Q35. The collector of Q35 is connected to pin 3 of QA7. When Q35 is turned on, the voltage at its collector goes low and



BLOCK DIAGRAM

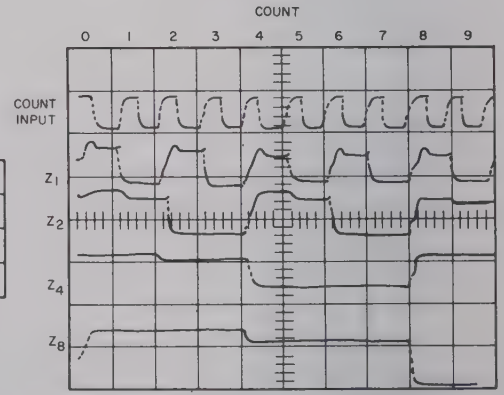


BASE CONNECTIONS

	0	1	2	3	4	5	6	7	8	9
Z_1	H	L	H	L	H	L	H	L	H	L
Z_2	H	H	L	L	H	H	L	L	H	H
Z_4	H	H	H	H	L	L	L	L	H	H
Z_8	H	H	H	H	H	H	H	H	L	L

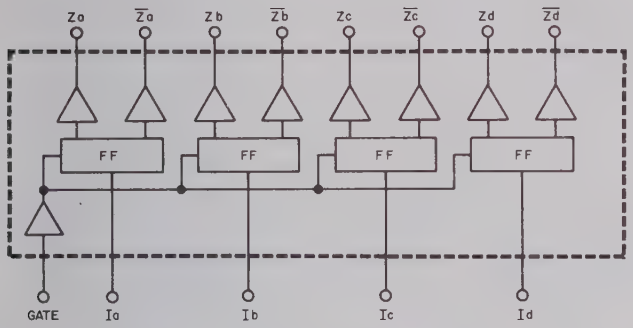
(H = HIGH L = LOW)

TRUTH TABLE



OUTPUT WAVEFORMS

Figure 4-7. FS CμL 958 Counter



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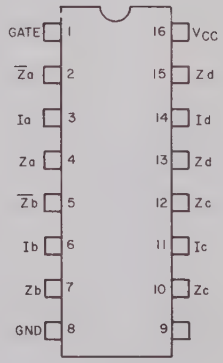


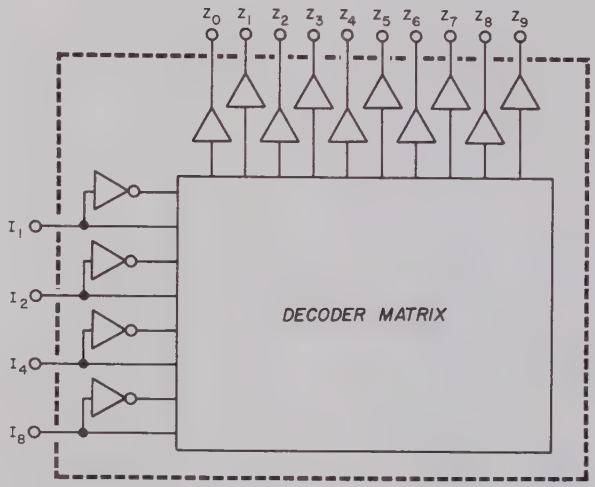
BASE CONNECTIONS

GATE	I	Z	$\overline{Z}$
L	L	L	H
L	H	H	L
H	ANY	Q	$\overline{Q}$

H = HIGH
L = LOW
Q = THE STATE ASSUMED PRIOR TO "GATE HIGH" IS MAINTAINED

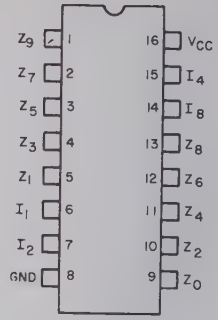
TRUTH TABLE

Figure 4-8. FS CμL 959 Buffer/Storage Element



BLOCK DIAGRAM

TOP VIEW



BASE CONNECTIONS

I_1	H	L	H	L	H	L	H	L	H	L
I_2	H	H	L	L	H	H	L	L	H	H
I_4	H	H	H	H	L	L	L	L	H	H
I_8	H	H	H	H	H	H	H	H	L	L
ON OUTPUT	Z_0	Z_1	Z_2	Z_3	Z_4	Z_5	Z_6	Z_7	Z_8	Z_9

H = HIG '
L = LOW

TRUTH TABLE

Figure 4-9. FS CμL 960 Decimal Decoder/Driver

QA7 is triggered. QA7 is an FS μL 926 JK flip-flop. Its function is to control bistable multivibrator Q31/Q32 which operates DS3. Q31 and Q32 normally are held off and CR10, CR11 are back biased. During the strobe pulse, the voltage at the emitters of Q31 and Q32 drops. This allows the output state of QA7 to be sampled. If pin 7 is high and pin 9 is low, CR11 becomes forward biased; Q32 is turned on and Q31 is turned off. When Q32 is on, Q40 is allowed to conduct. This creates a voltage drop across DS3 and a "1" appears as the most significant digit in the readout.

4-40. CHOPPER DRIVE

4-41. The chopper in the chopper amplifier is an FI100 MOS FET. Operation of an FI100 is such that the gate must be biased approximately 4 V negative with respect to the source before the device will turn on. The chopper drive circuit has been designed to produce a square waveform that alternates between +1.2 V and -6 V. The positive 1.2 V signal is necessary because of the junction drop across CR2 and Q13 (see figure 4-10). Chopper drive is derived from the clock and counter as follows: QA8 is the third FS CμL 958 element in the series decade counters. The first two counter elements divide the 24 KHz clock output by 100. The first flip-flop circuit in QA8 divides the 240 Hz input to QA8 by two. The resultant 120 Hz output at pin 3 of QA8 triggers driver Q38. The

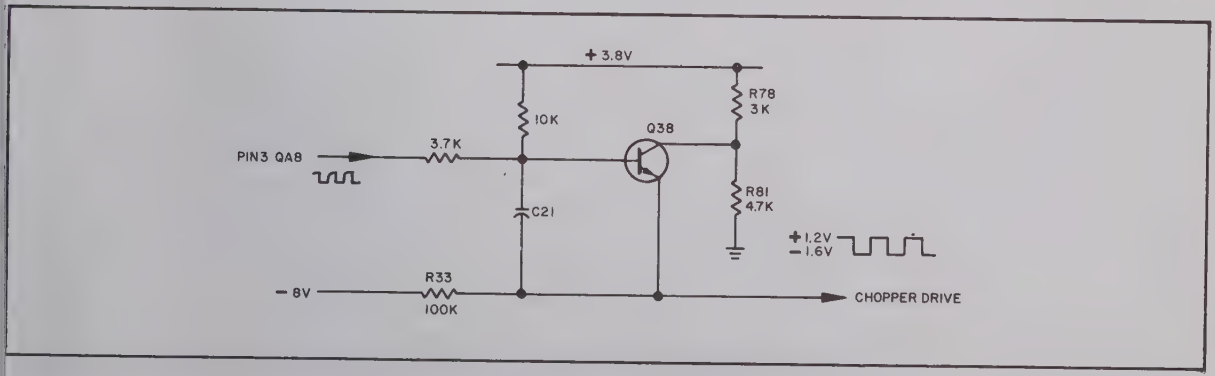


Figure 4-10. Chopper Drive Circuit

square waveform appearing at the collector of Q38 alternates between +1.2 V and -6 V. This output is used to drive chopper Q16 and solid state switch Q13.

4-42. OHMS CONVERTER

4-43. The ohms converter (figure 4-11) is switch into the measurement circuit when an OHMS range is selected on the Function/Range switch. The ohms converter includes a bootstrap amplifier that produces two outputs. One output is used for the 15 MΩ range only. This output adds 1 V to the voltage at the amplifier input. The other output is used for all OHMS ranges except 15 MΩ. This output adds 10 V to the amplifier input. When a particular OHMS range is selected, the appropriate output voltage is connected to the low end of the attenuator. The attenuator. The attenuator programs a test current that flows through the unknown resistance connected between the OHMS and COMMON terminals. Test currents are 0.1 μA (15 MΩ range), 1μA (1.5 MΩ range), 0.01 mA (150 kΩ range), 0.1 mA (15 kΩ range), and 1 mA (1.5 kΩ range).

4-44. The voltage drop across the unknown resistor is measured with the dc voltage measuring portion of the instrument.

4-45. Q4 is a current source for the ohms converter. The zener breakdown potential of CR1 provides reference for the current source. Current from Q4 flows through R52, R54, R55, and through Q30. Q27 and Q28 comprise a differential amplifier. The voltage at the base of Q27 is always directly proportional to the value of the unknown resistance. An increase in V_{in} causes Q27 to conduct less and Q28 to conduct more. This causes Q25 to conduct harder because of the increased voltage appearing at R52. The voltage at the base of Q26 rises to follow the voltage at the base of Q25 and hence to remain 10 V above the voltage at the input to the ohms converter (base of Q27). By this action, the output at the base of Q26 is always equal to the voltage at the base of Q27 plus 10 volts.

4-46. The output for the 15 MΩ range appears on the wiper arm of R55. Because of the bootstrap action, this output voltage is always 1 volt above the voltage at the base of Q27.

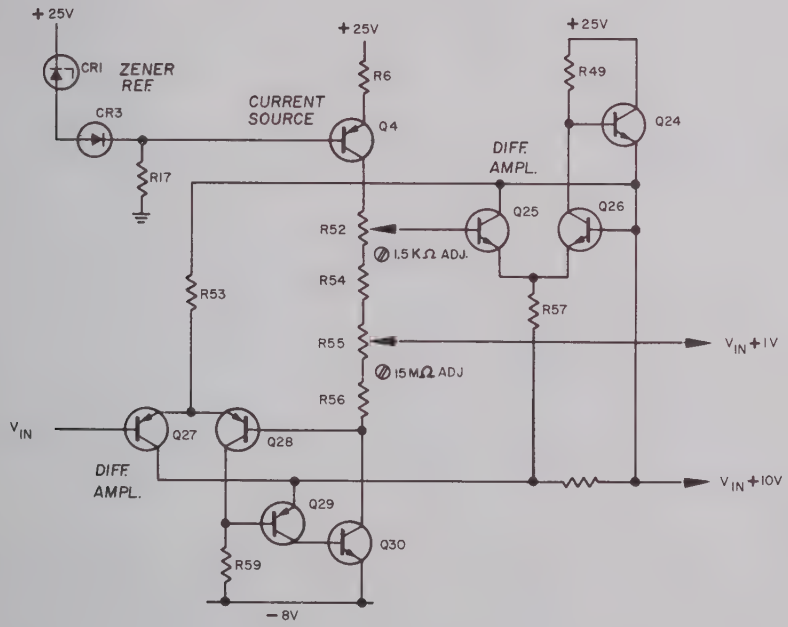


Figure 4-11. Ohms Converter

4-47. POWER SUPPLY

4-48. The power supply in the Model 7050 produces output levels of +220 V, +25 V, +3.8 V, and -8 V. The +220 V output is used to supply anode potentials for display tubes and lamps. The +25 V and -8 V supplies are used in control logic and the analog-to-digital (A-D) converter. The +3.8 V supply is used with the low-level micrologic elements.

4-49. The +220 V output is taken from the secondary of T1 and full-wave rectified by CR7 and CR8. Capacitor C16 reduces ripple in the +220 V output.

4-50. Reference for the +25 V, +3.8 V, and -8 V supply outputs is established by the zener breakdown of CR14. This zener diode is a S20943 transistor that has its collector lead open circuited and its base and emitter terminals connected as shown in figure 4-12. The emitter-to-base breakdown potential of CR14 establishes reference voltage at the emitter of Q37. The base lead of Q37 is connected to the junction of sensing resistors R74, R80. Any variation in the +25 V output is sensed across these two resistors and detected at the base of Q37. If the output voltage decreases due to a load change, the decrease will cause Q37 to conduct less. The voltage at the base of series regulator Q33 rises. Hence Q33 conducts harder and compensates for the drop in output voltage. C26 is an output filter for the +25 V supply.

4-51. The +25 V supply provides reference for the -8 V supply. Sensing resistors R84 and R85 are connected between the +25 V output and the -8 V output. Assuming that the +25 V output is absolutely stable, the slightest variation in the -8 V output will be sensed across R84 and R85. The variation is sensed at the base of Q39. For instance, a drop in the output voltage (less negative) causes the voltage at the base of Q39 to rise and Q39 conducts less. The voltage at the base of Q41 drops and Q41 conducts harder to accomplish regulation. CR15 rectifies the transformer output and C23 filters the rectified input signal. Resistors R73 and R75 comprise a voltage divider that fixes the voltage at the base of Q36. Q36 acts as a constant current source and fixes the voltage at the base of Q34. If the voltage at the emitter of Q34 tends to drop, Q34 will conduct harder and compensate for the drop. The 3.8 V output is also dependent on the +25 V supply.

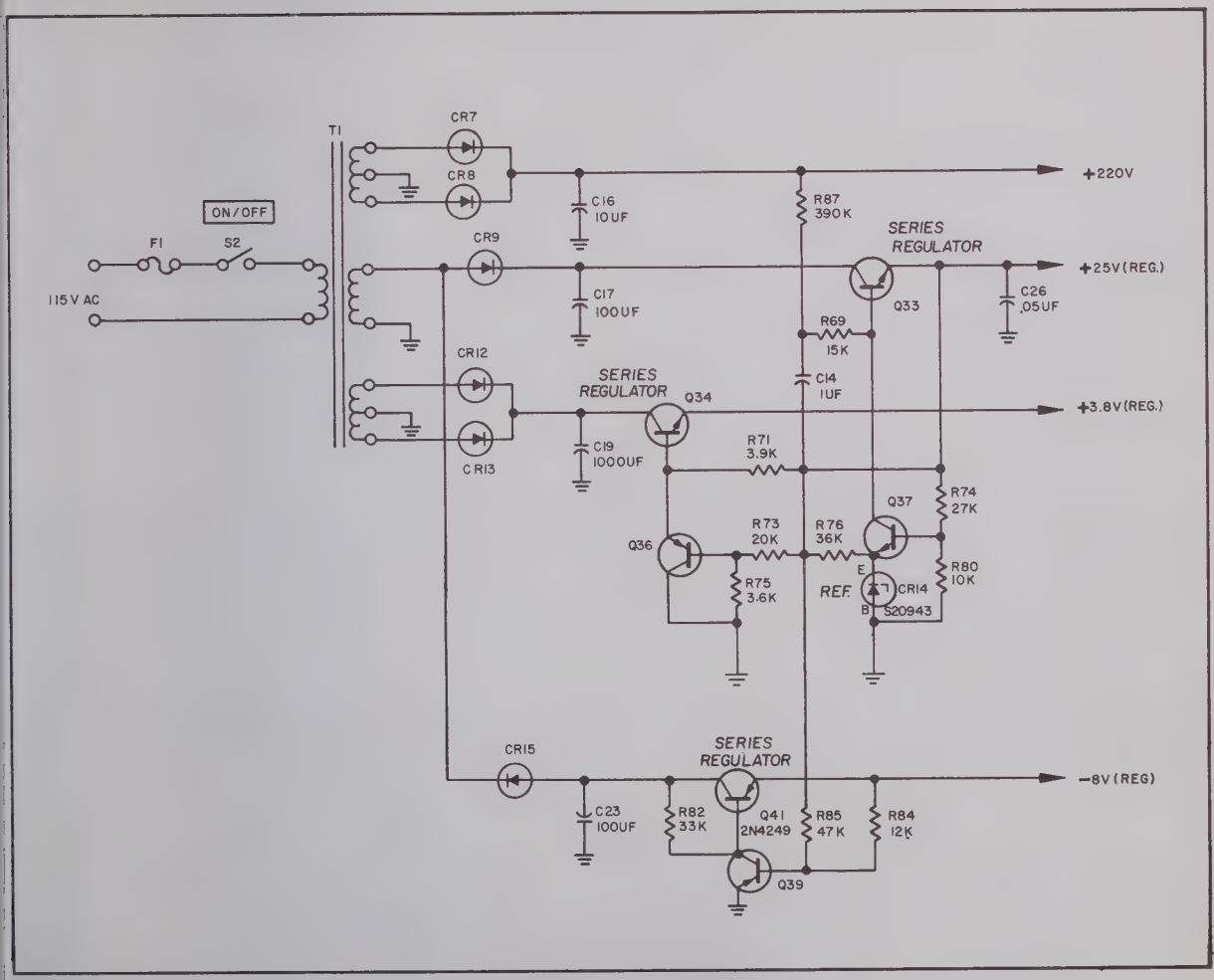


Figure 4-12. Power Supply

SECTION V
MAINTENANCE

5-1. INTRODUCTION

5-2. This section contains information for calibration, maintenance, and trouble-shooting of the Model 7050.

5-3. TEST EQUIPMENT REQUIRED

5-4. Table 5-1 lists test equipment required for checking performance, trouble-shooting and calibration for the Model 7050.

5-5. In procedures involving accurate dc voltage or resistance measurements, care must be taken to ensure consistent results. Working standards should be referred to primary standards on a regular basis. Particular care should be taken with resistance standards that are subject to long-term drift due to aging.

5-6. PERFORMANCE CHECK

5-7. The performance check outlined in the following paragraphs is used to verify the specifications of the Model 7050. It can be used upon receipt of a new instrument, for routine preventive maintenance, and following repair.

NOTE

If the instrument fails to meet the performance check at any time, proceed to the appropriate calibration procedure to correct the malfunction.

Table 5-1. Required Test Equipment

Equipment Type	Purpose	Required Specification	Recommended Instrument
DC Voltage Standard	DC voltage alignment and calibration	Accuracy: ±0.02% Range: 1 mV to 1000 V	Fluke Model 332A
Resistance Standard	Resistance alignment and calibration	Accuracy: ±0.05% Range: 1 Ω to 15 MΩ	Electro Scientific Industries Model DB 877
Auto-Transformer	Line voltage check	Range: 60 to 130 Vac 2A max. current	General Radio Type W5MT3W
Oscilloscope	Troubleshooting	Vertical Sensitivity: 5 mV	Fairchild Model 767H
DC Current Standard	Provide dc current for optional DC current operational check	Current Range: 0.1 μA to 1A Accuracy: 0.02%	Fluke Model 382A

5-8. VOLTAGE ACCURACY CHECK

5-9. To check dc voltage measurement accuracy, proceed as follows:

a. Connect power cord to 115 Vac source and make following initial front panel control settings:

Function/Range switch. . . . . VOLTS/1.5 V
ON/OFF switch. . . . . ON

b. Connect a short between VOLTS and COMMON terminals on Model 7050. Check that readout is between 0.000 and ±0.001. Remove short from VOLTS and COMMON terminals.

c. Set output of voltage standard to zero. Connect VOLTS and COMMON terminals on Model 7050 to (+) and (-) output terminals respectively on voltage standard.

d. Consult table 5-2 and set voltage standard to output levels listed. Select appropriate Range setting on Model 7050. Check that in each case readout is within tolerance given.

e. Reverse polarity of voltage standard and repeat tests listed in table 5-2. Check that all readings are within tolerance, but of opposite polarity.

f. Reduce voltage standard to zero and remove input leads from Model 7050.

Table 5-2. DC Voltage Measurement Accuracy at 25°C

Voltage Standard	Function/Range Switch Setting	Readout Limits	
		Minimum	Maximum
Input Short	Volts/1.5V	±.000	±.001
+0.003 Vdc	Volts/1.5V	+.002	+.004
+0.010 Vdc	Volts/1.5V	+.009	+.011
+0.100 Vdc	Volts/1.5V	+.099	+.101
+0.500 Vdc	Volts/1.5V	+.499	+.501
+1.000 Vdc	Volts/1.5V	+.998	+1.002
+1.500 Vdc	Volts/1.5V	+1.498	+1.502
+01.50 Vdc	Volts/15V	+1.49	+1.51
+15.00 Vdc	Volts/15V	+14.98	+15.02
+015.0 Vdc	Volts/150V	+14.9	+15.1
+150.0 Vdc	Volts/150V	+149.8	+150.2
+0150 Vdc	Volts/1KV	+149	+151
+1000 Vdc	Volts/1KV	+998	+1002

5-10. CURRENT ACCURACY CHECK

5-11. To check resistance measurement accuracy, proceed as follows:

a. Connect power cord to 115 Vac sources and make following initial front panel control settings:

Function/Range switch. . . . . VOLTS/1.5 V
ON/OFF switch. . . . . ON

b. Connect precision 10 KΩ current shunt across VOLTS - COMMON terminals as described in figure 3-4. Connect dc current standard in series with precision shunt.

CAUTION

TAKE CARE THAT TEST CURRENT DOES NOT EXCEED FULL SCALE CURRENT INDICATED ON PRECISION SHUNT BEING USED. EXCESSIVE CURRENT WILL CAUSE PERMANENT DAMAGE TO THE PRECISION SHUNT RESISTOR.

c. Consult table 5-4 and set current standard to values listed. Check that in each case readout is within tolerance given. NOTE: Conventional current (defined as flowing from (+) to (-)) will produce a + indication as it flows into the side of the precision shunt that is connected to the VOLTS terminal and out of the side that is connected to the COMMON terminal.

d. Remove current standard from Model 7050.

Table 5-4. DC Current Measurement Accuracy at 25°C

Model 7050 Function/Range	Current Shunt	Standard dc Current	Readout Limits	
			Maximum	Minimum
1.5 V	10 kΩ	0.000	+.001	-.001
	10 kΩ	+75.00 μA	+.753	+.747
	10 kΩ	+150.0 μA	+1.504	+1.496
	1 kΩ	+0.500 mA	+.502	+.498
	1 kΩ	+1.000 mA	+1.003	+.997
	1 kΩ	+1.500 mA	+1.504	+1.496
	100 Ω	+5.00 mA	+.502	+.502
	100 Ω	+10.00 mA	+1.003	+.997
	100 Ω	+15.00 mA	+1.504	+1.496
	10 Ω	+50 mA	+.502	+.498
	10 Ω	+100 mA	+1.003	+.997
	10 Ω	+150 mA	+1.504	+1.496
	1 Ω	+0.500 A	+.503	+.497
	1 Ω	+1.000 A	+1.005	+.995
	1 Ω	+1.500 A	+1.507	+1.493

5-12. RESISTANCE ACCURACY CHECK

5-13. To check resistance measurement accuracy, proceed as follows:

a. Connect power cord to 115 Vac line voltage source and make following front panel control settings:

Function/Range switch. OHMS/1.5K
ON/OFF switch. . . . . ON

b. Connect resistance standard between OHMS and COMMON terminals on Model 7050.

c. Consult table 5-4 and set resistance standard to values listed. Set Model 7050 Function/Range switch to appropriate settings. Check that in each case readout is within tolerance given.

d. Remove resistance standard from Model 7050.

5-14. CALIBRATION PROCEDURE

5-15. Figure 5-1 details the procedure required to calibrate the Model 7050 and also identifies the calibration controls at the rear of the instrument.

5-16. PARTS LOCATION AND SCHEMATIC

5-17. Figure 5-2 shows the location of all components contained in the Model 7050 and figure 5-3 is a detailed schematic of the unit.

Table 5-4. Resistance Measurement Accuracy at 25°C

Resistance Standard	Function/Range Switch Setting	Readout Limits	
		Minimum	Maximum
0.000	Ohms/1.5K	.000	.001
0.003 kΩ	Ohms/1.5K	.002	.004
0.100 kΩ	Ohms/1.5K	.099	.101
0.500 kΩ	Ohms/1.5K	.498	.502
1.000 kΩ	Ohms/1.5K	.997	1.003
1.500 kΩ	Ohms/1.5K	1.496	1.504
01.50 kΩ	Ohms/15K	1.49	1.51
15.00 kΩ	Ohms/15K	14.96	15.04
015.0 kΩ	Ohms/150K	14.9	15.1
150.0 kΩ	Ohms/150K	149.6	150.4
0.150 MΩ	Ohms/1.5M	.148	.152
1.500 MΩ	Ohms/1.5M	1.484	1.516
01.50 MΩ	Ohms/15M	1.46	1.54
15.00 MΩ	Ohms/15M	14.69	15.31

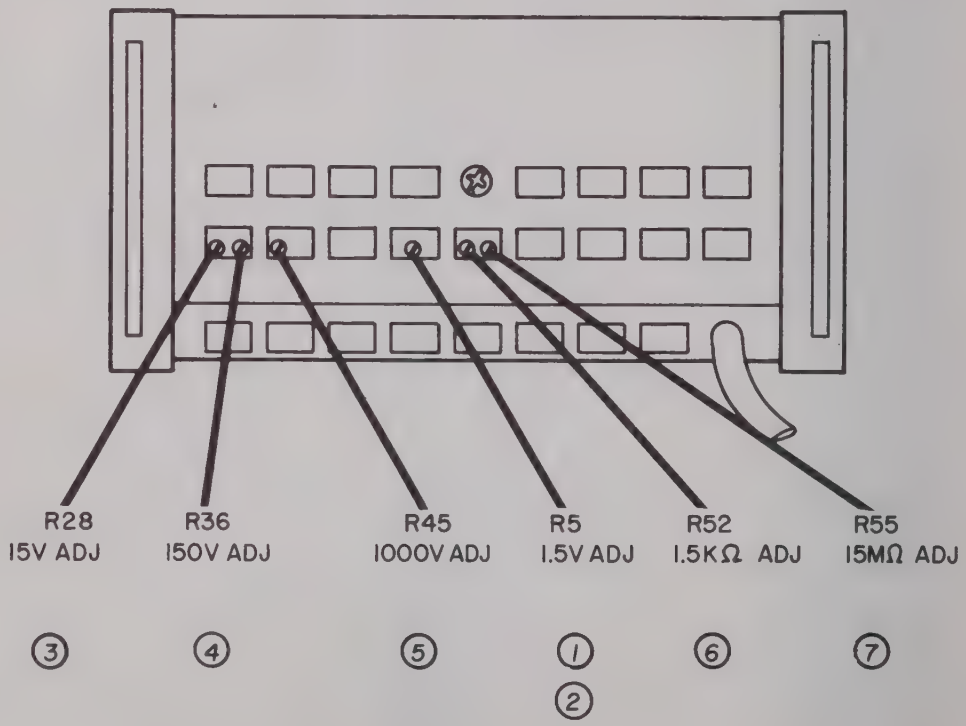


Figure 5-1. Calibration Procedure

Step	Function/Range Switch Setting	Input	Adjustment
1	Volts/1.5 V	+1.500 Vdc	Adjust R5 for readout of +1.500
2	Volts/1.5 V	-1.500 Vdc	No adjustment. Readout should be -1.500 ±1 digit.
3	Volts/15 V	+15.00 Vdc	Adjust R28 for readout of +15.00
4	Volts/150 V	+150.0 Vdc	Adjust R36 for readout of +150.0
5	Volts/1 KV	+1000.0 Vdc	Adjust R45 for readout of +1000
6	Ohms/1.5 K	1.500 kΩ	Adjust R52 for readout of 1.500
7	Ohms/15 M	15.000 MΩ	Adjust R55 for readout of 15.00

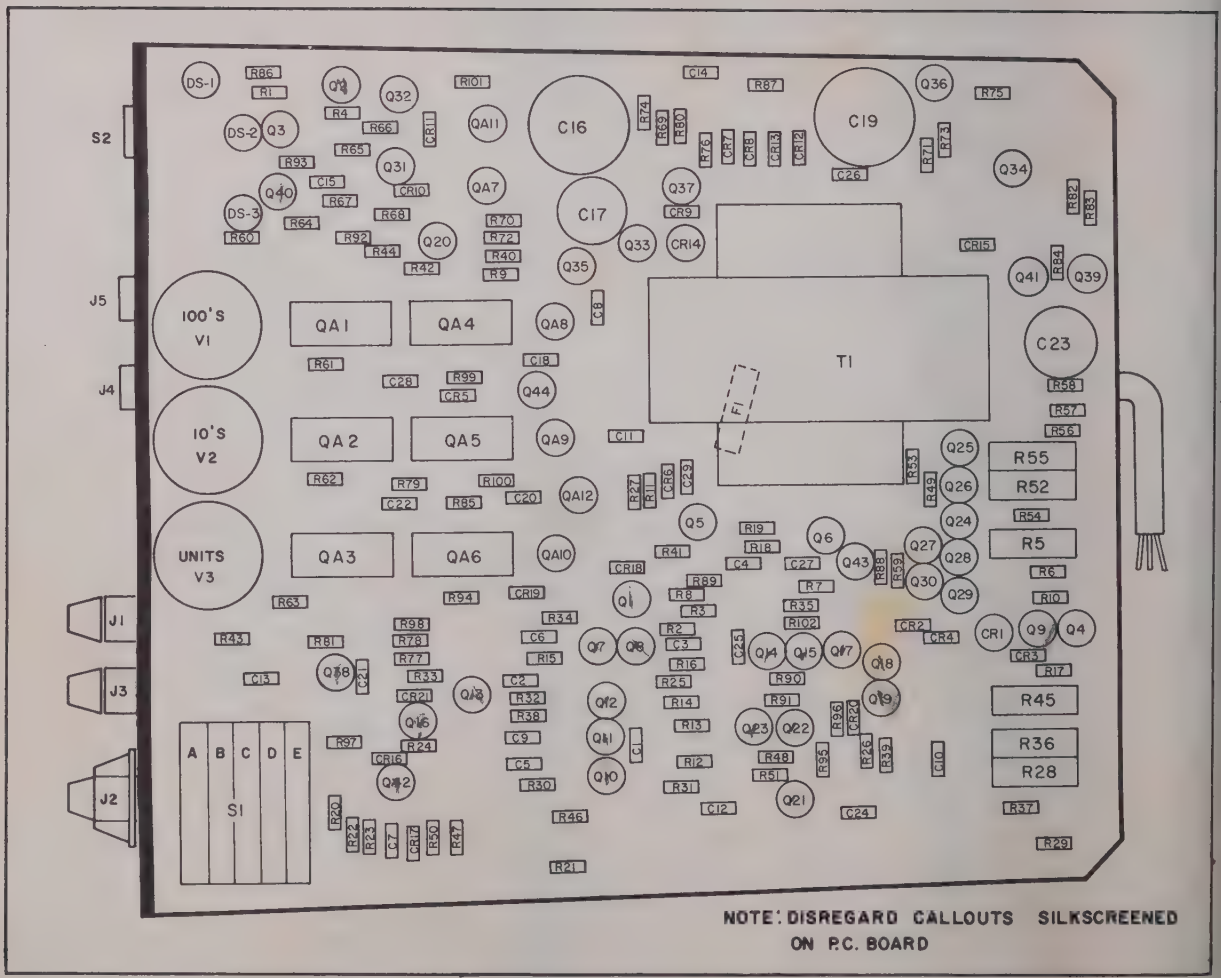


Figure 5-2. Component Location

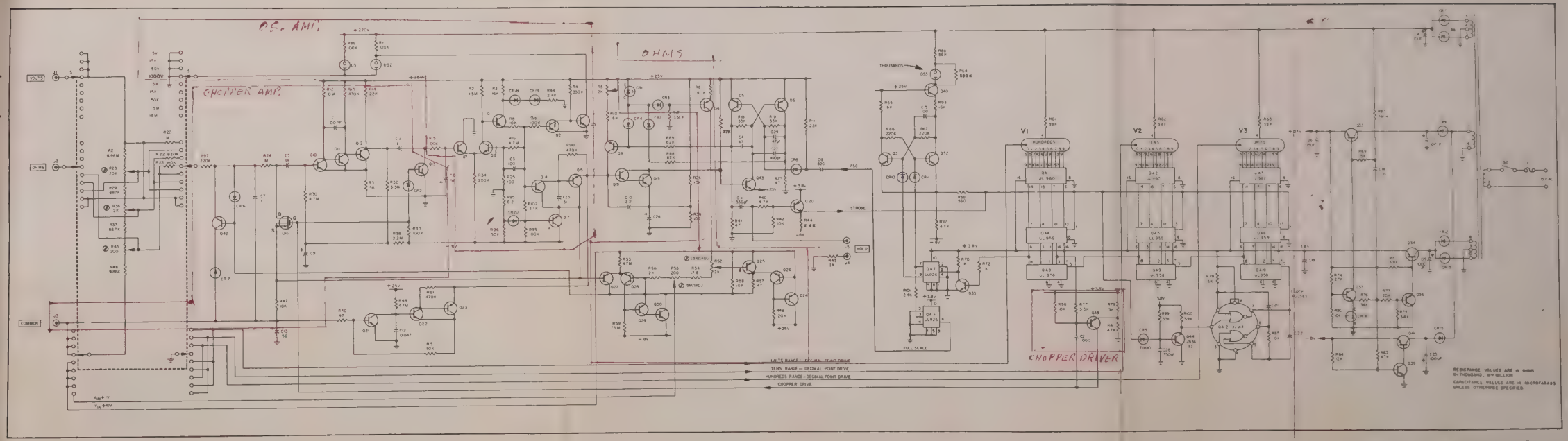


Figure 5-3. Model 7050 Schematic Diagram

SECTION VI
REPLACEMENT PARTS

6-1. GENERAL

6-2. Table 6-1 contains information for ordering replacement parts and lists: circuit reference, description, manufacturer, and Fairchild Instrumentation part number. Physical location of electrical components and mechanical items are called out in section V and are cross-referenced with the parts list through the circuit reference numbers.

6-3. ORDERING INFORMATION

6-4. To order a replacement part, address the order to an authorized Fairchild Instrumentation sales representative, or to: 475 Ellis Street, Mountain View, California.

6-5. Specify the following for each part:

a. Model and serial number of instrument.

b. Fairchild Instrumentation part number.

c. Circuit reference designation, assembly number, or complete description.

6-6. To order a part not listed in table 6-1, provide a complete description of the part, including function and location.

ABBREVIATIONS

AB	Allen-Bradley Co.	Fusetron	Bussmen Fuse Co.
Amelco	Amelco Semiconductor	GE	General Electric Co.
Amperex	Amperex Electric Corp.	Griffith Plastics	Griffith Plastic Products Co.
Beckman	Beckman Instruments, Inc.	IRC	International Resistance Co.
Belden	Belden Manufacturing Co.	Nat'l Elect	National Electronics, Inc.
CTS	Chicago Telephone Supply	Mallory	P.R. Mallory and Co.
Continental-Wirt	Continental-Wirt Co.	RCL	RCL Electronics, Inc.
Elmenco	The Electro Motive Mfg. Co.	Tranex	Tranex, Inc.
Erie	Erie Technological Prod. Inc.	TRW	TRW Capacitor Div.
FS	Fairchild Semiconductor	Wakefield	Wakefield Engineering, Inc.

Table 6-1. Model 7050 List of Replacement Parts

Circuit Reference	Description	Manufacturer	FI Part Number
C1	Capacitor, fixed, 100 pF, 500 V	Amperex	03286450
C2	Capacitor, fixed, 0.1 μF ±10%, 100 V	Amperex	03285150
C3	Same as C1		
C4	Capacitor, fixed, 47 pF, 500 V	Amperex	03286430
C5	Capacitor, fixed, 0.01 μF ± 10%, 200V	TRW	03278910
C6	Capacitor, fixed, 56 μF, 6 V		03279560
C7	Same as C2		
C8	Capacitor, fixed, 820 pF, MICA 300V		03281560
C9	Capacitor, fixed, 1 μF, 35V TANT.	Sprague	03282660
C10	Capacitor, fixed, 2.2 μF, 250 V	Amperex	03281280
C11	Capacitor, fixed, 330 pF, 500 V	Elmenco	03281450
C12	Capacitor, fixed, 0.047 μF ±10%, 100 V	Amperex	03285110
C13	Same as C6		
C14	Same as C9		
C15	Same as C1		
C16	Capacitor, fixed, 10 μF, 350 V	Mallory	03286660
C17	Capacitor, fixed, 100 μF, 64 V	Amperex	03286630
C18	Same as C2		
C19	Capacitor, fixed, 1000 μF, 10 V	Amperex	03286600
C20	Capacitor, fixed, 3300 pF ±10%, 100 V	Erie	03287140
C21	Capacitor, fixed, 1000 pF, 500 V	Amperex	03286510

Table 6-1. Model 7050 List of Replacement Parts (Cont.)

Circuit Reference	Description	Manufacturer	FI Part Number
C22	Same as C20		
C23	Same as C17		
C24	Same as C9		
C25	Capacitor, fixed, 51 pF, 500V	Elmenco	03175210
C26	Capacitor, fixed, 0.05 μF, 50 V		03281790
C27	Same as C1		
C28	Capacitor, fixed, 750 pF, 300 V		03270170
C29	Same as C4		
CR1	Diode, S20944	FS	26004001
CR2	Diode, FD100	FS	26006930
CR3	Same as CR2		
CR4	Same as CR2		
CR5	Same as CR2		
CR6	Same as CR2		
CR7	Diode, 1N4005		26012270
CR8	Same as CR7		
CR9	Diode, 1N4003		26011080
CR10	Same as CR2		
CR11	Same as CR2		
CR12	Same as CR9		26011080
CR13	Same as CR9		
CR14	Diode, S20943	FS	26003991

Table 6-1. Model 7050 List of Replacement Parts (Cont.)

Circuit Reference	Description	Manufacturer	FI Part Number
CR15	Same as CR9		
CR16	Diode, FD300		26012320
CR17	Same as CR16		
CR18	Same as CR2		
CR19	Same as CR2		
CR20	Same as CR2		
CR21	Same as CR2		
DS1	Lamp, neon, NE-2U	GE	12013110
DS2	Same as DS1		
DS3	Same as DS1		
F1	Fuse, 0.1 A, 250 V, SB	Fusetron	11007130
J1	Jack, red, binding post		09064470
J2	Jack, white, binding post		09064490
J3	Jack, black, binding post		09064480
J4	Jack, black, banana		09056700
J5	Same as J4		
QA1	Micrologic element, type CμL 960		26012430
QA2	Same as QA1		
QA3	Same as QA1		
QA4	Micrologic element, type CμL 959		26012420
QA5	Same as QA4		

Table 6-1. Model 7050 List of Replacement Parts (Cont.)

Circuit Reference	Description	Manufacturer	FI Part Number
QA6	Same as QA4		
QA7	Micrologic element, type CμL 926		26011940
QA8	Micrologic element, type CμL 958		26012410
QA9	Same as QA8		
QA10	Same as QA8		
QA11	Same as QA7		
QA12	Micrologic element, type CμL 914	FS	26010980
Q1	Transistor, 2N3565		26012000
Q2	Same as Q1		
Q3	Transistor, 2N720A		26010850
Q4	Transistor, 2N4249	FS	26013260
Q5	Transistor, 2N4122	FS	26012160
Q6	Same as Q5		
Q7	Transistor, 2N2484		26010670
Q8	Same as Q7		
Q9	Transistor, 2N4250	FS	26014430
Q10	Same as Q7		
Q11	Same as Q1		
Q12	Same as Q1		
Q13	Transistor, 2N3564		26012620
Q14	Same as Q7		
Q15	Same as Q4		

Table 6-1. Model 7050 List of Replacement Parts (Cont.)

Circuit Reference	Description	Manufacturer	FI Part Number
Q16	Transistor, 2N4120 MOS FET	FS	26014410
Q17	Same as Q4		
Q18	Same as Q7		
Q19	Same as Q1		
Q20	Same as Q5		
Q21	Same as Q1		
Q22	Same as Q7		
Q23	Same as Q4		
Q24	Same as Q1		
Q25	Same as Q1		
Q26	Same as Q1		
Q27	Same as Q4		
Q28	Same as Q4		
Q29	Same as Q4		
Q30	Same as Q1		
Q31	Same as Q1		
Q32	Same as Q1		
Q33	Same as Q3		
Q34	Transistor, 2N3300		26013940
Q35	Same as Q1		
Q36	Same as Q4		
Q37	Same as Q1		

Table 6-1. Model 7050 List of Replacement Parts (Cont.)

Circuit Reference	Description	Manufacturer	FI Part Number
Q38	Same as Q4		
Q39	Same as Q4		
Q40	Same as Q3		
Q41	Same as Q4		
Q42	Same as Q7		
Q43	Same as Q5		
Q44	Same as Q13		
R1	Resistor, fixed 100 k ±5%, 1/2 W	Amperex	02393391
R2	Resistor, fixed, 1.5M ±5%, 1/4 W	AB	02355370
R3	Resistor, fixed, 16 k ±5%, 1/4 W	Amperex	02040771
R4	Resistor, fixed, 330 k ±5%, 1/4W	Amperex	02041081
R5	Resistor, variable, 2 k	Beckman	01111090
R6	Resistor, fixed, 14.1 k, 2 W	RCL	02402920
R7	Resistor, fixed, 27 k ±5%, 1/4 W	Amperex	02040821
R8	Resistor, fixed, 10 k ±5%, 1/4 W	Amperex	02040721
R9	Resistor, fixed, 100 k ±5%, 1/4 W	Amperex	02040961
R10	Resistor, fixed, 16 k ±1%, 2 W	RCL	02402930
R11	Resistor, fixed, 22 k ±5%, 1/4 W	Amperex	02040801
R12	Resistor, fixed, 10 M ±5%, 1/4 W	A-B	02355570
R13	Resistor, fixed, 470 k ±5%, 1/4 W	Amperex	02041121
R14	Same as R11		
R15	Same as R9		

Table 6-1. Model 7050 List of Replacement Parts (Cont.)

Circuit Reference	Description	Manufacturer	FI Part Number
R16	Resistor, fixed, 4.7 M ±5%, 1/2 W	AB	02355490
R17	Same as R4		
R18	Resistor, fixed, 33 k ±5%, 1/4 W	Amperex	02040841
R19	Same as R18		
R20	Resistor, fixed, 1 M ±5%, 1/2 W	AB	02031200
R21	Resistor, fixed, 8.96 M ±.5%, 2 W	IRC	02402880
R22	Resistor, fixed, 820 k ±5%, 1/4 W	Amperex	02041181
R23	Resistor, fixed, 910 k ±5%, 1/4 W	Amperex	02041191
R24	Resistor, fixed, 1 M ±5%, 1/4 W	Amperex	02041201
R25	Same as R9		
R26	Same as R8		
R27	Resistor, fixed, 47 k ±5%, 1/4 W	Amperex	02040881
R28	Resistor, variable, 20 k	Beckman	01111100
R29	Resistor, fixed 887 k ±5%, 1/4 W	IRC	02402890
R30	Same as R16		
R31	Resistor, fixed, 56 Ω ±5%, 1/4 W	Amperex	02040181
R32	Resistor, fixed, 3.3 M ±5%, 1/4 W	AB	02355450
R33	Same as R9		
R34	Resistor, fixed, 220 k ±5%, 1/4 W	Amperex	02041041
R35	Same as R9		
R36	Same as R5		
R37	Resistor, fixed, 88.7 k ±5%, 1/4 W	IRC	02402900

Table 6-1. Model 7050 List of Replacement Parts (Cont.)

Circuit Reference	Description	Manufacturer	FI Part Number
R38	Resistor, fixed, 2.2 M ±5%, 1/4 W	AB	02355410
R39	Same as R8		
R40	Resistor, fixed, 4.7 k ±5%, 1/4 W	Amperex	02040641
R41	Same as R27		
R42	Same as R8		
R43	Resistor, fixed, 1 k ±5%, 1/4 W	Amperex	02040481
R44	Resistor, fixed, 2.4 k ±5%, 1/4 W	Amperex	02040571
R45	Resistor, variable, 200 Ω ±10%, 1 W	Beckman	01111080
R46	Resistor, fixed, 9.86 k ±5%, 1 W	IRC	02402870
R47	Resistor, fixed, 10 k ±1%, 2 W	RCL	02402910
R48	Same as R16		
R49	Resistor, fixed, 120 k ±5%, 1/4 W	Amperex	02040981
R50	Resistor, fixed, 47 Ω ±5%, 1/4 W	Amperex	02040161
R51	Same as R8		
R52	Same as R5		
R53	Same as R16		
R54	Resistor, fixed, 17.8 k ±1%, 2 W	RCL	02402940
R55	Same as R45		
R56	Resistor, fixed, 2 k ±1%, 1/2 W	RCL	02402950
R57	Same as R27		
R58	Same as R8		
R59	Resistor, fixed, 7.5 M ±5%, 1/4 W	AB	02355540
R60	Resistor, fixed, 39K ±5%, 1/4W	AB	02040861

Table 6-1. Model 7050 List of Replacement Parts (Cont.)

Circuit Reference	Description	Manufacturer	FI Part Number
R61	Same as R60		
R62	Same as R60		
R63	Same as R60		
R64	Resistor, fixed, 390 k ±5%, 1/4W	Amperex	02041101
R65	Same as R3		
R66	Same as R34		
R67	Same as R34		
R68	Resistor, fixed, 560 Ω ±5%, 1/4 W	Amperex	02040421
R69	Resistor, fixed, 15 k ±5%, 1/4 W	Amperex	02040761
R70	Same as R43		
R71	Resistor, fixed, 3.9 k ±5%, 1/4 W	Amperex	02040621
R72	Same as R43		
R73	Resistor, fixed, 20 k ±5%, 1/4 W	Amperex	02040791
R74	Resistor, fixed, 27 k ±5%, 1/4 W	Amperex	02040821
R75	Resistor, fixed, 3.6 k ±5%, 1/4 W	Amperex	02040611
R76	Resistor, fixed, 36 k ±5%, 1/4 W	Amperex	02040851
R77	Resistor, fixed, 3.3 k ±5%, 1/4 W	Amperex	02040601
R78	Resistor, fixed, 3 k ±5%, 1/4 W	Amperex	02040591
R79	Same as R69		
R80	Same as R8		
R81	Same as R40		
R82	Same as R18		

Table 6-1. Model 7050 List of Replacement Parts (Cont.)

Circuit Reference	Description	Manufacturer	FI Part Number
R83	Same as R27		
R84	Resistor, fixed, 12 k ±5%, 1/4 W	Amperex	02040741
R85	Same as R8		
R86	Same as R1		
R87	Same as R64		
R88	Resistor, fixed, 82 k ±5%, 1/4 W	Amperex	02040941
R89	Same as R88		
R90	Same as R13		
R91	Same as R13		
R92	Same as R40		
R93	Same as R3		
R94	Same as R44		
R95	Resistor, fixed, 6.2 k ±5%, 1/4 W	Amperex	02040671
R96	Resistor, fixed, 30 k ±5%, 1/4 W	Amperex	02040831
R97	Same as R34		
R98	Same as R8		
R99	Same as R18		
R100	Same as R71		
R101	Same as R44		
S1	Switch, rotary, PC lugs	CTS	05019071
S2	Switch, SPST	Continental-Wirt	05034990
T1	Transformer, PC lugs	Tranex	20017001

Table 6-1. Model 7050 List of Replacement Parts (Cont.)

Circuit Reference	Description	Manufacturer	FI Part Number
V1	Tube, readout NL 848	Nat'l Elect.	25015510
V2	Same as V1		
V3	Same as V1		
XV1	Socket, tube	Nat'l Elect.	34011530
XV2	Same as XV1		
XV3	Same as XV1		
	Miscellaneous		
	Case	FI	33041040
	Cord, a-c power	Belden	50304520
	Extrusion foot, rubber	FI	38020041
	Heatsink, transistor	Wakefield	27004400
	Knob, selector	Griffith Plastics	45011360
	Lens, light pipe	FI	48006701
	Lens, ± light	FI	48006721
	Lens, readout, red		48006691
	Lockwasher, #4		62200010
	Manual, Instruction		67050971
	Nut, 4-40		61039290
	Pad, transistor		41012340
	Plug, handle, Mtg, hole		
	Screw, 4-40 x 1-3/8		60112580
	Shield, light		

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